

# GPS IV

## Relativity of Simultaneity & the Sagnac Effect

### An Aether Cosmology Presentation

by

## Space Audits

---

$$1) v = v_0 + at$$

$$2) \Delta x = \left(\frac{v+v_0}{2}\right)t$$

$$3) \Delta x = v_0 t + \frac{1}{2}at^2$$

$$4) v^2 = v_0^2 + 2a\Delta x$$

Note:

- Eq. 3 is supposed to end in  $t^2$

Changes in velocity over time

Change in location over time

Acceleration

No casual mechanism, just when/where and how fast

<https://byjus.com/physics/kinematics-examples-in-real-life/> 

Notes:

$$\nu = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = c$$

Notes:

History of c, u and e.

the reciprocal sq of mag perm and electric perm is c

Kinematics is a science of mathematical abstraction that uses kinematic variables to model generic patterns of motion. T. Phipps Jr has used the Hertz EM laws and kinematic invariants of first power of ten in  $v/c$  to develop a general solution to EM tests of motion, such as the Fresnel formula described here.

**Proper time: a key kinematic invariant.**

A key component of the derivation is the use of proper time, the time a clock measures in the rest frame of an observer, and the coordinate time as measured by a clock in motion relative to the rest frame observer. The two are related as:

$$d^2\tau = dt^2 - (dx^2 + dy^2 + dz^2)/c^2$$

Notes:

- Maxwell - Not implicit to SR
- Based on

The Hertz EM laws, which replace Maxwell's partial derivatives with total time derivatives, introducing thereby laws that are Galilean covariant(not Lorentzian)...and an additional parameter, a convective velocity ...of aether,  $V_a$ .

The claim of Special Relativity to derive the Fresnel Drag equation is a consequence of Galilean relativity's replacement of  $t' = t$  with the proper time,  $\tau = t \sqrt{1 - v^2/c^2}$  ...corresponding to time dilation in the Lorentz transform. But in the Galilean model,  $d' = d$ , at odds with the length contraction of Lorentz relativity.

The time components explains the similarity in the Fresnel formula; the difference in the space components accounts for the difference in second order of  $v/c$ .  
aether and motion

- Cassandar's Hertz derivation of Maxwell's Eqs

The Hertz EM laws, which replace Maxwell's partial derivatives with total time derivatives, introducing thereby laws that are Galilean covariant(not Lorentzian)...and an additional parameter, a convective velocity ...of aether,  $V_a$ .

The claim of Special Relativity to derive the Fresnel Drag equation is a consequence of Galilean relativity's replacement of  $t' = t$  with the proper time,  $\tau = t \sqrt{1 - v^2/c^2}$  ...corresponding to time dilation in the Lorentz transform. But in the Galilean model,  $d' = d$ , at odds with the length contraction of Lorentz relativity.

The time components explains the similarity in the Fresnel formula; the difference in the space components accounts for the difference in second order of  $v/c$ .

- Bethell, Tom. "Questioning Einstein: Is Relativity Necessary?" 6, no. 2 (2010).

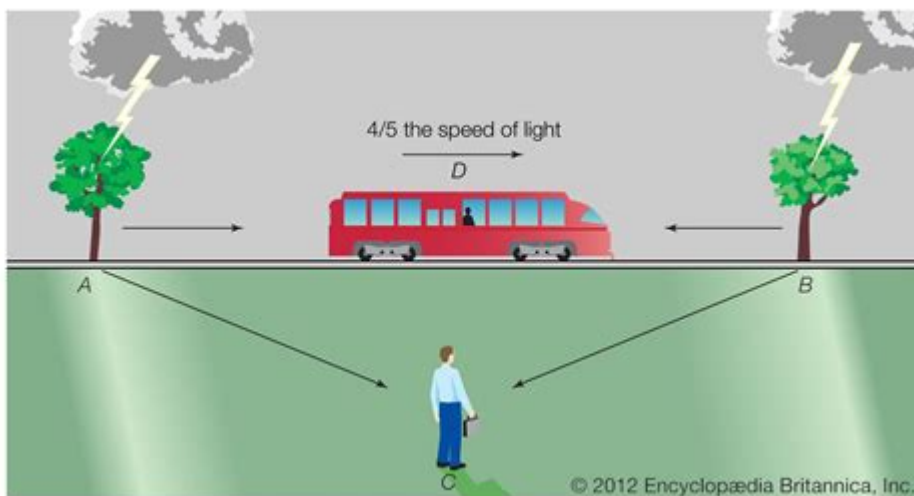
---

Experiments leading up to Relativity Theory

Notes:

James Bradley, Arago, Airy, Fizzie-o, and MMX

---



Notes:

---

# ON THE ELECTRODYNAMICS OF MOVING BODIES

BY A. EINSTEIN

June 30, 1905

Examples of this sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the “light medium,” suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.<sup>1</sup> We will raise this conjecture (the purport of which will hereafter be called the “Principle of Relativity”) to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity  $c$  which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell’s theory for stationary bodies. The introduction of a “luminiferous ether” will prove to be superfluous inasmuch as the view here to be developed will not require an “absolutely stationary space” provided with special properties, nor

<sup>1</sup>The preceding memoir by Lorentz was not at this time known to the author.

assign a velocity-vector to a point of the empty space in which electromagnetic processes take place.

The theory to be developed is based—like all electrodynamics—on the kinematics of the rigid body, since the assertions of any such theory have to do with the relationships between rigid bodies (systems of co-ordinates), clocks, and electromagnetic processes. Insufficient consideration of this circumstance lies at the root of the difficulties which the electrodynamics of moving bodies at present encounters.

Notes:

What are these equations and where do they apply?

- Posties Laws of physics (motion) are the same in all inertial ref. frames



- $c$  is constant & independent of source the velocity of the source or observer

## I. KINEMATICAL PART

### § 1. Definition of Simultaneity

Let us take a system of co-ordinates in which the equations of Newtonian mechanics hold good.<sup>2</sup> In order to render our presentation more precise and to distinguish this system of co-ordinates verbally from others which will be introduced hereafter, we call it the “stationary system.”

If a material point is at rest relatively to this system of co-ordinates, its position can be defined relatively thereto by the employment of rigid standards of measurement and the methods of Euclidean geometry, and can be expressed in Cartesian co-ordinates.

If we wish to describe the *motion* of a material point, we give the values of its co-ordinates as functions of the time. Now we must bear carefully in mind that a mathematical description of this kind has no physical meaning unless we are quite clear as to what we understand by “time.” We have to take into account that all our judgments in which time plays a part are always judgments of *simultaneous events*. If, for instance, I say, “That train arrives here at 7 o’clock,” I mean something like this: “The pointing of the small hand of my watch to 7 and the arrival of the train are simultaneous events.”<sup>3</sup>

Notes:

- introduce time to describe motion
- speed is  $d/t$
- logically coherent so far

in respect of time, an event at A with an event at B. We have so far defined only an “A time” and a “B time.” We have not defined a common “time” for A and B, for the latter cannot be defined at all unless we establish *by definition* that the “time” required by light to travel from A to B equals the “time” it requires to travel from B to A. Let a ray of light start at the “A time”  $t_A$  from A towards B, let it at the “B time”  $t_B$  be reflected at B in the direction of A, and arrive again at A at the “A time”  $t'_A$ .

In accordance with definition the two clocks synchronize if

$$t_B - t_A = t'_A - t_B.$$

We assume that this definition of synchronism is free from contradictions, and possible for any number of points; and that the following relations are universally valid:—

1. If the clock at B synchronizes with the clock at A, the clock at A synchronizes with the clock at B.
2. If the clock at A synchronizes with the clock at B and also with the clock at C, the clocks at B and C also synchronize with each other.

Thus with the help of certain imaginary physical experiments we have settled what is to be understood by synchronous stationary clocks located at different places, and have evidently obtained a definition of “simultaneous,” or “synchronous,” and of “time.” The “time” of an event is that which is given simultaneously with the event by a stationary clock located at the place of the event, this clock being synchronous, and indeed synchronous for all time determinations, with a specified stationary clock.

In agreement with experience we further assume the quantity

$$\frac{2AB}{t'_A - t_A} = c,$$

to be a universal constant—the velocity of light in empty space.

It is essential to have time defined by means of stationary clocks in the stationary system, and the time now defined being appropriate to the stationary system we call it “the time of the stationary system.”

Notes:

- Simultaneous events in one frame may not be simultaneous in another frame moving relative to the first.
- As a consequence of the finite speed of light and the principle of relativity, events experienced in a ref. frame occur wrt observer velocity.
- Distinguishing **time** from a universe construct (*absolute*) to a **proper time** in one's own rest frame (*relative*).

- Coordinate System Time vs Proper Time
- Divergences in proper time intervals is length contraction and time dilation
- Stationary system K, moving K'
- Time dilation and length contraction are a ratio (gamma) of the speed of light to the velocity of the moving observer with respect to a stationary observer
- SR predictions a specific clock sync protocol

---


$$\frac{2AB}{t'_A - t_A} = c$$

Notes:

Two stationary clocks A & B

$t' = t \Rightarrow c = c \rightarrow 1AB = c$

Kinematics = true

Dynamics = false

---

## § 2. On the Relativity of Lengths and Times

The following reflexions are based on the principle of relativity and on the principle of the constancy of the velocity of light. These two principles we define as follows:—

let it be reflected at B at the time  $t_B$ , and reach A again at the time  $t'_A$ . Taking into consideration the principle of the constancy of the velocity of light we find that

$$t_B - t_A = \frac{r_{AB}}{c - v} \text{ and } t'_A - t_B = \frac{r_{AB}}{c + v}$$

where  $r_{AB}$  denotes the length of the moving rod—measured in the stationary system. Observers moving with the moving rod would thus find that the two clocks were not synchronous, while observers in the stationary system would declare the clocks to be synchronous.

So we see that we cannot attach any *absolute* signification to the concept of simultaneity, but that two events which, viewed from a system of co-ordinates, are simultaneous, can no longer be looked upon as simultaneous events when envisaged from a system which is in motion relatively to that system.

Notes:

- in short; moving observer would measure a path length and time change proportional to their velocity wrt c and would not the same distances and times for a stationary observer.
  - absolute space & time
-

### § 3. Theory of the Transformation of Co-ordinates and Times from a Stationary System to another System in Uniform Motion of Translation Relatively to the Former

Let us in “stationary” space take two systems of co-ordinates, i.e. two systems, each of three rigid material lines, perpendicular to one another, and issuing from a point. Let the axes of X of the two systems coincide, and their axes of Y and Z respectively be parallel. Let each system be provided with a rigid measuring-rod and a number of clocks, and let the two measuring-rods, and likewise all the clocks of the two systems, be in all respects alike.

It follows from this relation and the one previously found that  $\phi(v) = 1$ , so that the transformation equations which have been found become

$$\begin{aligned}\tau &= \beta(t - vx/c^2), \\ \xi &= \beta(x - vt), \\ \eta &= y, \\ \zeta &= z,\end{aligned}$$

where

$$\beta = 1/\sqrt{1 - v^2/c^2}.$$

Notes:

- Gamma is a function of the squared velocity ratio

- $\left(\frac{v^2}{c^2}\right)$

To sum this up briefly ; there is no variance in c proportional v that would cause time and distances to change.

Yet, how can the two systems be equivalent? In physical reality, the observers time and distance contract and dilate as a ratio of their velocity to c given by this equation:  $\beta = 1/\sqrt{1 - v^2/c^2}$ .

- S2 = Absolute space =>  $c+v \neq c$
- S3 = Physical reality contraction and dilation wrt another observer
- Gamma factor serves as the dynamic mechanism for the invariance of c regarding relative motion or gravitational field potential

- Resultant from the constancy of  $c$ , you'll never be able to measure your translator motion because you'll already be contracted by  $\gamma$ , which is also why two events occurring simultaneous to a stationary observer will not be observed as simultaneous for you.

## § 4. Physical Meaning of the Equations Obtained in Respect to Moving Rigid Bodies and Moving Clocks

From this there ensues the following peculiar consequence. If at the points A and B of K there are stationary clocks which, viewed in the stationary system, are synchronous; and if the clock at A is moved with the velocity  $v$  along the line AB to B, then on its arrival at B the two clocks no longer synchronize, but the clock moved from A to B lags behind the other which has remained at

B by  $\frac{1}{2}tv^2/c^2$  (up to magnitudes of fourth and higher order),  $t$  being the time occupied in the journey from A to B.

It is at once apparent that this result still holds good if the clock moves from A to B in any polygonal line, and also when the points A and B coincide.

If we assume that the result proved for a polygonal line is also valid for a continuously curved line, we arrive at this result: If one of two synchronous clocks at A is moved in a closed curve with constant velocity until it returns to A, the journey lasting  $t$  seconds, then by the clock which has remained at rest the travelled clock on its arrival at A will be  $\frac{1}{2}tv^2/c^2$  second slow. Thence we conclude that a balance-clock<sup>7</sup> at the equator must go more slowly, by a very small amount, than a precisely similar clock situated at one of the poles under otherwise identical conditions.

Notes:

- Where do these equations hold true?
- Uniformly rotating systems
- Special note to the polygon in UNIFORM translatory motion



## § 5. The Composition of Velocities

$$1 + vw \cos \alpha / c$$

It is worthy of remark that  $v$  and  $w$  enter into the expression for the resultant velocity in a symmetrical manner. If  $w$  also has the direction of the axis of  $X$ , we get

$$V = \frac{v + w}{1 + vw/c^2}.$$

It follows from this equation that from a composition of two velocities which are less than  $c$ , there always results a velocity less than  $c$ . For if we set  $v = c - \kappa$ ,  $w = c - \lambda$ ,  $\kappa$  and  $\lambda$  being positive and less than  $c$ , then

$$V = c \frac{2c - \kappa - \lambda}{2c - \kappa - \lambda + \kappa\lambda/c} < c.$$

It follows, further, that the velocity of light  $c$  cannot be altered by composition with a velocity less than that of light. For this case we obtain

$$V = \frac{c + w}{1 + w/c} = c.$$

We might also have obtained the formula for  $V$ , for the case when  $v$  and  $w$  have the same direction, by compounding two transformations in accordance with § 3. If in addition to the systems  $K$  and  $k$  figuring in § 3 we introduce still another system of co-ordinates  $k'$  moving parallel to  $k$ , its initial point moving on the axis of  $\Xi^\dagger$  with the velocity  $w$ , we obtain equations between the quantities  $x$ ,  $y$ ,  $z$ ,  $t$  and the corresponding quantities of  $k'$ , which differ from the equations found in § 3 only in that the place of “ $v$ ” is taken by the quantity

$$\frac{v + w}{1 + vw/c^2};$$

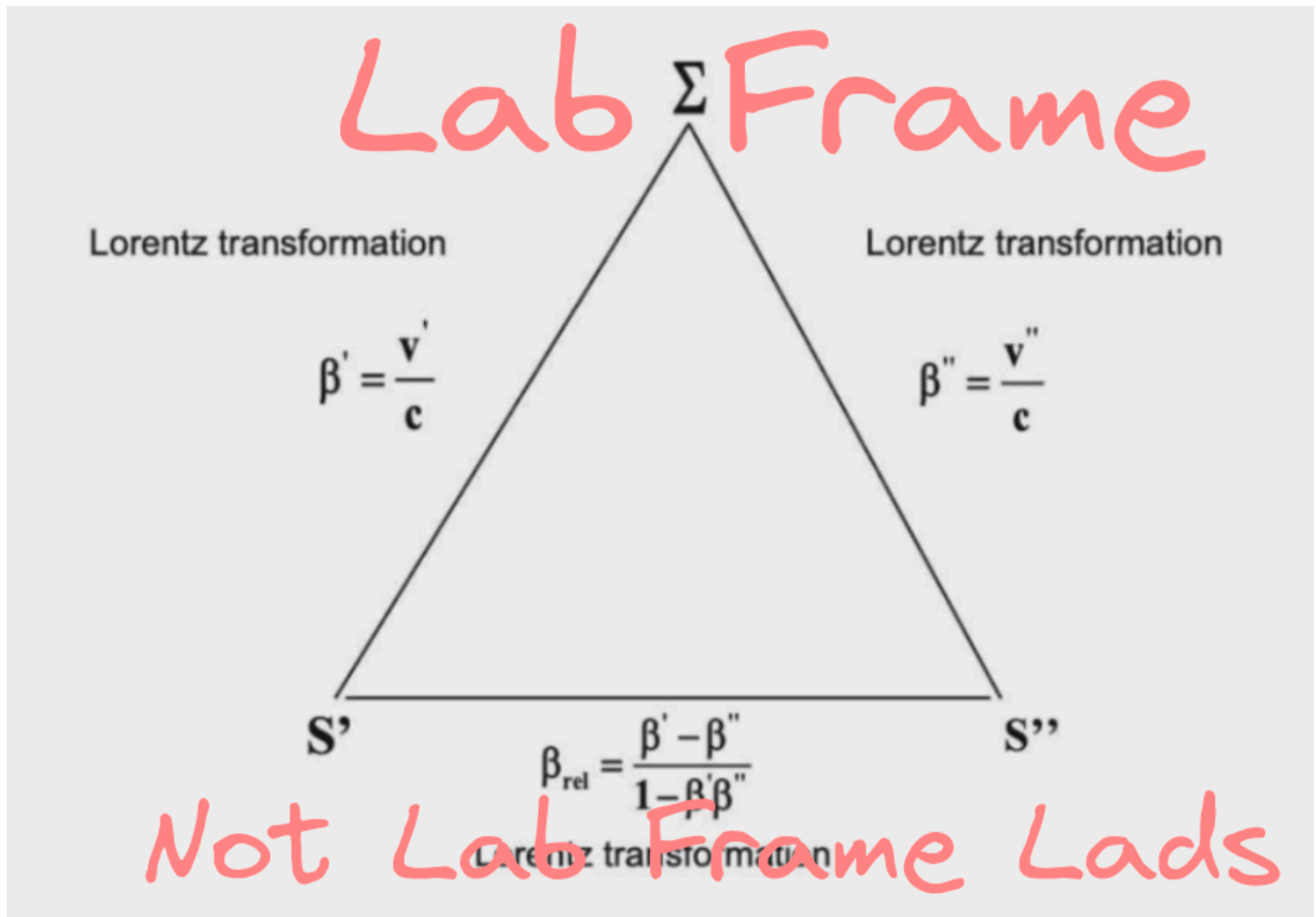
from which we see that such parallel transformations—necessarily—form a group.

We have now deduced the requisite laws of the theory of kinematics corresponding to our two principles, and we proceed to show their application to electrodynamics.

Notes:

- $1 + vw/c^2 = c$
- Relativistic correction to zero out velocity addition such that  $c$  is never exceeded should one of the velocities be  $c$  itself.





Notes:

- Important later for Lorentz Boosts
- Consoli, Maurizio, and Alessandro Pluchino. "Michelson-Morley Experiments: At the Crossroads of Relativity, Cosmology and Quantum Physics." *International Journal of Modern Physics A* 38, no. 35n36 (December 30, 2023): 2330017.  
<https://doi.org/10.1142/S0217751X2330017X>

| i  | July 8 (n.) | July 9 (n.) | July 11 (n.) | July 8 (e.) | July 9 (e.) | July 12 (e.) |
|----|-------------|-------------|--------------|-------------|-------------|--------------|
| 1  | −0.001      | +0.018      | +0.016       | −0.016      | +0.007      | +0.036       |
| 2  | +0.024      | −0.004      | −0.034       | +0.008      | −0.015      | +0.044       |
| 3  | +0.053      | −0.004      | −0.038       | −0.010      | +0.006      | +0.047       |
| 4  | +0.015      | −0.003      | −0.066       | +0.070      | +0.004      | +0.027       |
| 5  | −0.036      | −0.031      | −0.042       | +0.041      | +0.027      | −0.002       |
| 6  | −0.007      | −0.020      | −0.014       | +0.055      | +0.015      | −0.012       |
| 7  | +0.024      | −0.025      | +0.000       | +0.057      | −0.022      | +0.007       |
| 8  | +0.026      | −0.021      | +0.028       | +0.029      | −0.036      | −0.011       |
| 9  | −0.021      | −0.049      | +0.002       | −0.005      | −0.033      | −0.028       |
| 10 | −0.022      | −0.032      | −0.010       | +0.023      | +0.001      | −0.064       |
| 11 | −0.031      | +0.001      | −0.004       | +0.005      | −0.008      | −0.091       |
| 12 | −0.005      | +0.012      | +0.012       | −0.030      | −0.014      | −0.057       |
| 13 | −0.024      | +0.041      | +0.048       | −0.034      | −0.007      | −0.038       |
| 14 | −0.017      | +0.042      | +0.054       | −0.052      | +0.015      | +0.040       |
| 15 | −0.002      | +0.070      | +0.038       | −0.084      | +0.026      | +0.059       |
| 16 | +0.022      | −0.005      | +0.006       | −0.062      | +0.024      | +0.043       |

The 2nd-harmonic amplitudes for the six experimental sessions are reported in Table 2. Due to their statistical consistency, one can compute the mean and variance and obtain  $A_2^{\text{EXP}} \sim 0.016 \pm 0.006$ . This value is consistent with an observable velocity

$$v_{\text{obs}} \sim 8.5^{+1.7}_{-2.2} \text{ km/s} \quad (27)$$

Notes:

- original error bar  $\pm 0.004$  of a fringe
- **3σ** level: ~99.7% confidence
- **5σ** level: ~99.99994% confidence
- analyzed in a Fourier expansion
- The fringe shifts were much smaller than expected.
- In two experimental sessions (11 July noon and 12 July evening), the second-harmonic amplitude is non-zero at the 5σ level.
- In two other sessions (July 9 noon and July 8 evening), the second-harmonic amplitude is non-zero at the 3σ level.

- The average measured amplitude ( $A_{EXP2} \sim 0.016$ ) was much smaller than the classical expectation ( $A_{class} \sim 0.2$ ), but not completely negligible.

---

### 3.1. *The 1887 Michelson-Morley experiment in Cleveland*

The precision of the Michelson-Morley apparatus<sup>[33]</sup> was extraordinary, about  $\pm 0.004$  of a fringe. For all details, we address the reader to our book.<sup>[9]</sup> Here, we just limit ourselves to quote from Born.<sup>[49]</sup> When discussing the classically expected fringe shift upon rotation of the apparatus by 90 degrees, namely  $2A_2^{class} \sim 0.4$ , he says explicitly: “Michelson was certain that the one-hundredth part of this displacement would still be observable” (i.e. 0.004). As a check, the Michelson-Morley fringe shifts were recomputed in refs.<sup>[7][9][50]</sup> from the original article,<sup>[33]</sup> see Table 1. These data

Notes:

MMX accuracy and error tolerance

---

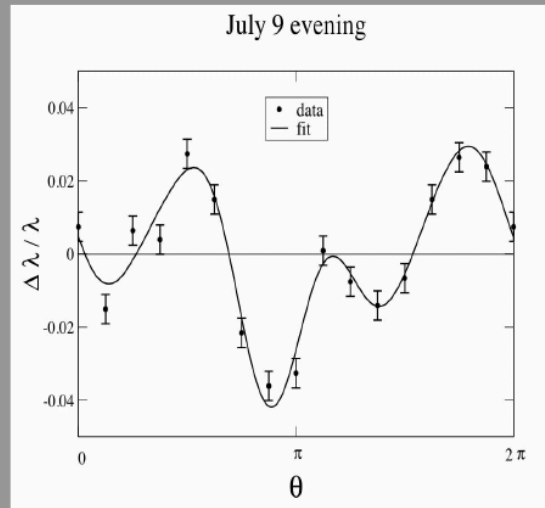


Fig. 5. The fringe shifts for the session of July 9 evening. The fit is performed by including terms up to fourth harmonics. The figure is taken from ref. [50](#)

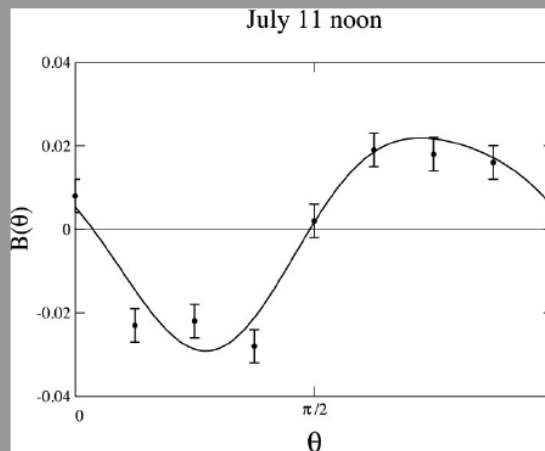


Fig. 6. A fit to the even combination  $B(\theta)$  Eq. [\(26\)](#). The second harmonic amplitude is  $A_2^{\text{EXP}} = 0.025 \pm 0.005$  and the fourth harmonic is  $A_4^{\text{EXP}} = 0.004 \pm 0.005$ . The figure is taken from ref. [50](#)

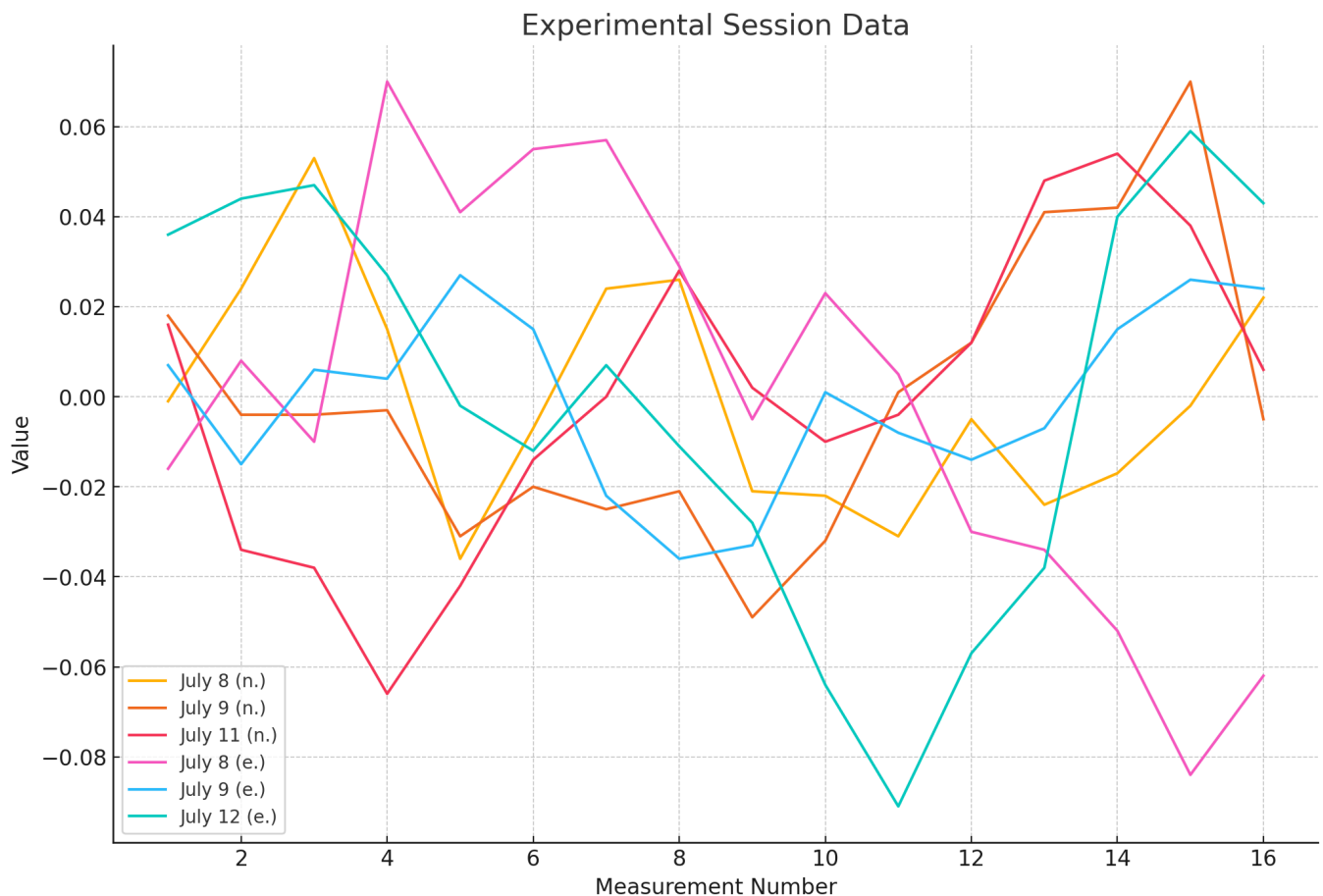
Notes:

- Does the sine wave intersect with the error bars?

## What is Harmonic Analysis?

- **Complex Signal Decomposition:** Breaks down complex measurement data into simpler sine and cosine waves (harmonics) using the Fourier Transform.

- **Filtering Noise:** Random noise appears as small, insignificant waves that get "washed out" in the harmonic analysis.
- **Identifying Meaningful Signals:** Statistically significant patterns emerge as distinct harmonics with measurable amplitudes.
- **Amplitude Measurement:** The strength of each harmonic component is indicated by its amplitude, which helps distinguish between noise and meaningful data.
- Miller & Thomas' Critiques - Didn't show his Fourier Xforms

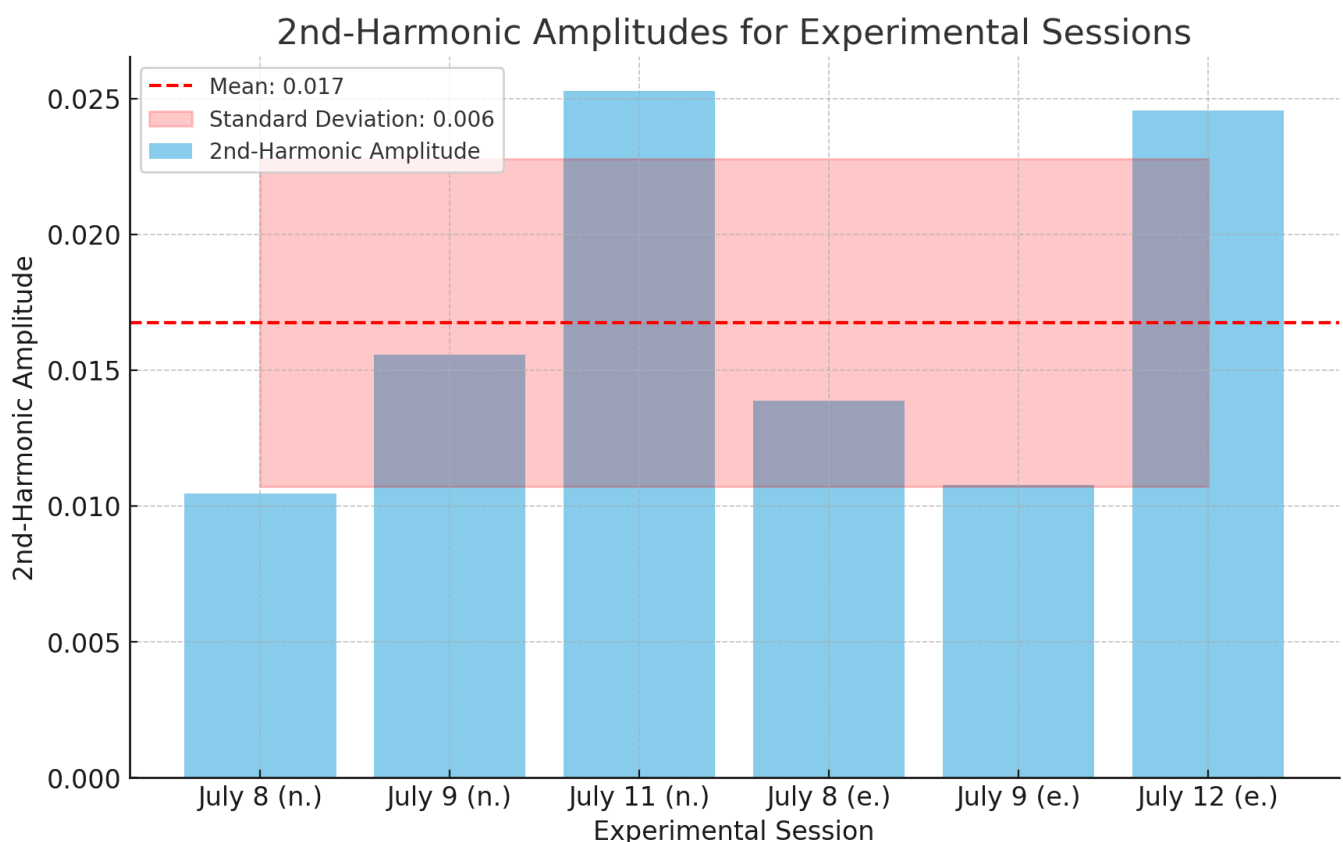


Notes:  
In your experiment:

1. **Fringe Shifts:** These are your initial measurements.
2. **Harmonic Analysis:** By decomposing these shifts into harmonics, you identify the 2nd

harmonic and measure its amplitude.

3. **Noise vs. Signal:** If the 2nd harmonic has a small or negligible amplitude, it might be just noise. If it has a significant amplitude, it indicates a real, meaningful effect.



Notes:

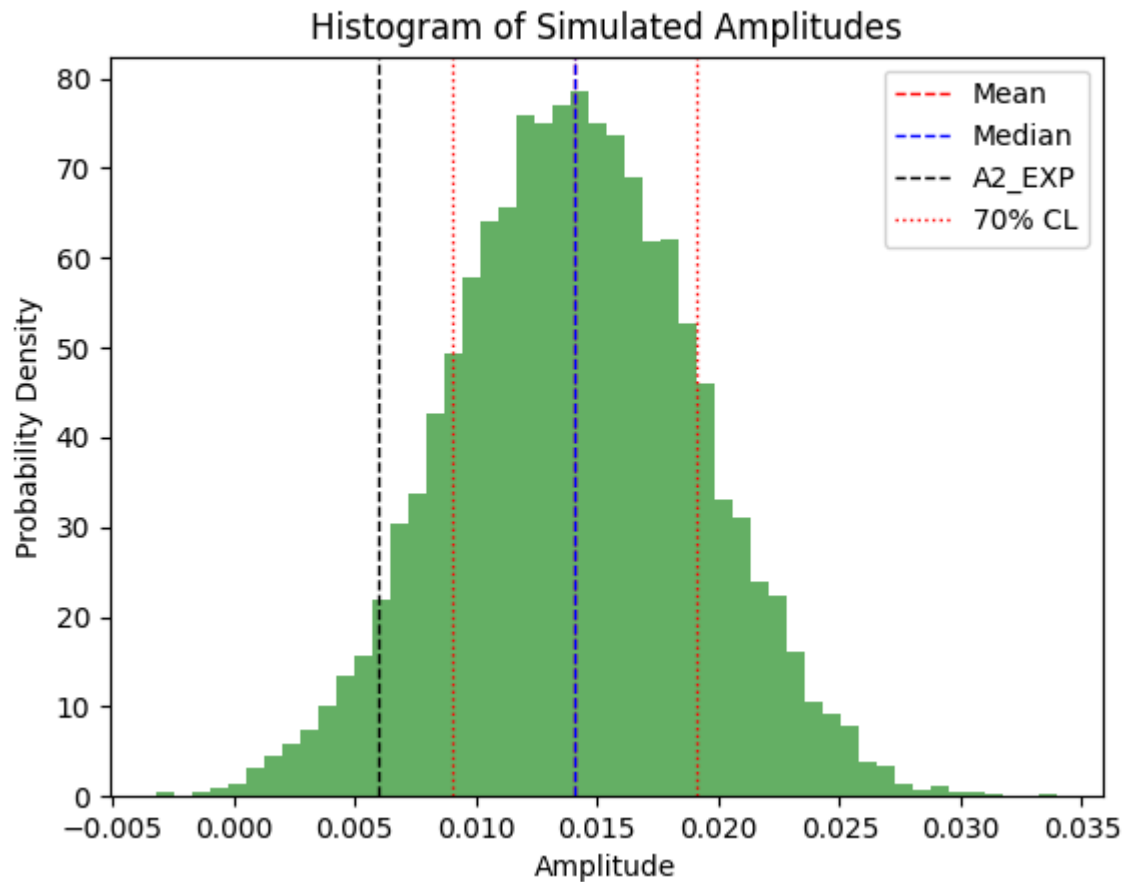
- **Consistency Across Sessions:** The 2nd-harmonic amplitudes are relatively consistent across the different experimental sessions. This suggests that the measurements are



reproducible and not significantly influenced by random fluctuations or experimental errors.

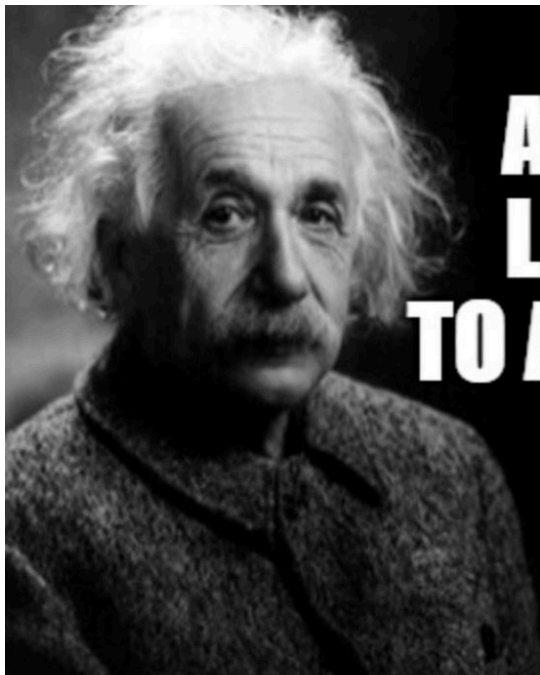
- **Mean Amplitude:** The calculated mean amplitude  $A_2^{\text{EXP}} \sim 0.016$  is much smaller than the classical expectation, yet it is not negligible. This indicates that while the measured values are lower than what classical theory predicts, there is a discernible 2nd-harmonic component present in the data.
- **Statistical Significance:** The error bar (standard deviation) of  $\pm 0.006$  around the mean amplitude suggests a relatively low level of measurement uncertainty. This implies that the observed 2nd-harmonic component is statistically significant and not due to random noise.
- **Observable Velocity:** The mean amplitude and its variance provide an estimate of an observable velocity  $v_{\text{obs}} \sim 8.5(\pm 1.7 \pm 2.2)$  km/s. This derived velocity, while not aligning

with classical expectations, still suggests the presence of a measurable effect.



Notes:

- Another harmonic analysis showing the minimum and maximum measured amplitudes are not statistic or experimental error.
- **SIMULATED DATA ANALYSIS**
- There's no experimentally measured constancy of  $c$ .
- $c$  as a constant is the rate of induction in light's inertial frame
- when light is propagating through a media, the induction rate is  $c \pm v$



# ALL I DID WAS CHANGE LORENTZ "LOCAL TIME" TO ANOTHER "REAL TIME"

discussed. One had only to realize that an auxiliary quantity introduced by H. A. Lorentz and named by him "local time" could be defined as "time" in general. If one adheres to this definition of time, the basic equations of Lorentz's theory correspond to the principle of relativity, provided that the above transformation equations are replaced by ones that correspond to the new conception of time. H. A. Lorentz's and FitzGerald's hypothesis appears then

[6]

-Albert Einstien

On the Principle of Doppler.

By  
W. Voigt.

It is known that the differential equations for the oscillations of an elastic incompressible medium read:

$$\frac{\partial^2 u}{dt^2} = \omega^2 \Delta u$$

$$\frac{\partial^2 v}{dt^2} = \omega^2 \Delta v$$

$$\frac{\partial^2 w}{dt^2} = \omega^2 \Delta w$$

1)

where  $\omega$  is the propagation velocity of the oscillations - or more precisely the propagation velocity of plane waves with constant amplitude. It is presupposed that  $u, v, w$  fulfill the relation:

Nachrichten  
von der  
Königlichen Gesellschaft der Wissenschaften  
und der  
Georg-Augusts-Universität  
zu Göttingen.

10. März. № 2. 1887.

3 Königl. Gesellschaft der Wissenschaften.

Sitzung vom 8. Januar.

Ueber das Doppler'sche Princip.

Von  
W. Voigt.

Die Differentialgleichungen für die Oscillationen eines elastischen incompressibeln Mediums sind bekanntlich:

$$\frac{\partial^2 u}{\partial t^2} = \omega^2 \Delta u$$

$$\frac{\partial^2 v}{\partial t^2} = \omega^2 \Delta v$$

$$\frac{\partial^2 w}{\partial t^2} = \omega^2 \Delta w$$

1)

Woldemar Voigt



Woldemar Voigt (1850-1919)

Dann wird sehr einfach, der Form nach naturgemäß mit identisch:

$$\begin{aligned} \xi_1 &= x_1 - vt \\ \eta_1 &= y_1 q \\ \zeta_1 &= z_1 q \\ \tau &= t - \frac{vx_1}{\omega^2}, \text{ wobei } q = \sqrt{1 - \frac{v^2}{\omega^2}} \text{ ist.} \end{aligned}$$

Divide everything by "q"  
or multiply everything by "1/q"

Moving Frame Velocity (v)

"Lorentz" Factor

Speed of Light (c)

Original Derivation of "Relativity" Math  
1887 - On the Principle Of Doppler  
by Woldemar Voigt

BS

Einstein's 1905 Copy of  
Voigt's "Relativity" Math

$$\begin{aligned} \tau &= \beta(t - vx/c^2), \\ \xi &= \beta(x - vt), \\ \eta &= y, \\ \zeta &= z, \\ \beta &= 1/\sqrt{1 - v^2/c^2}. \end{aligned}$$

This is Voigt's "q"

Notes:

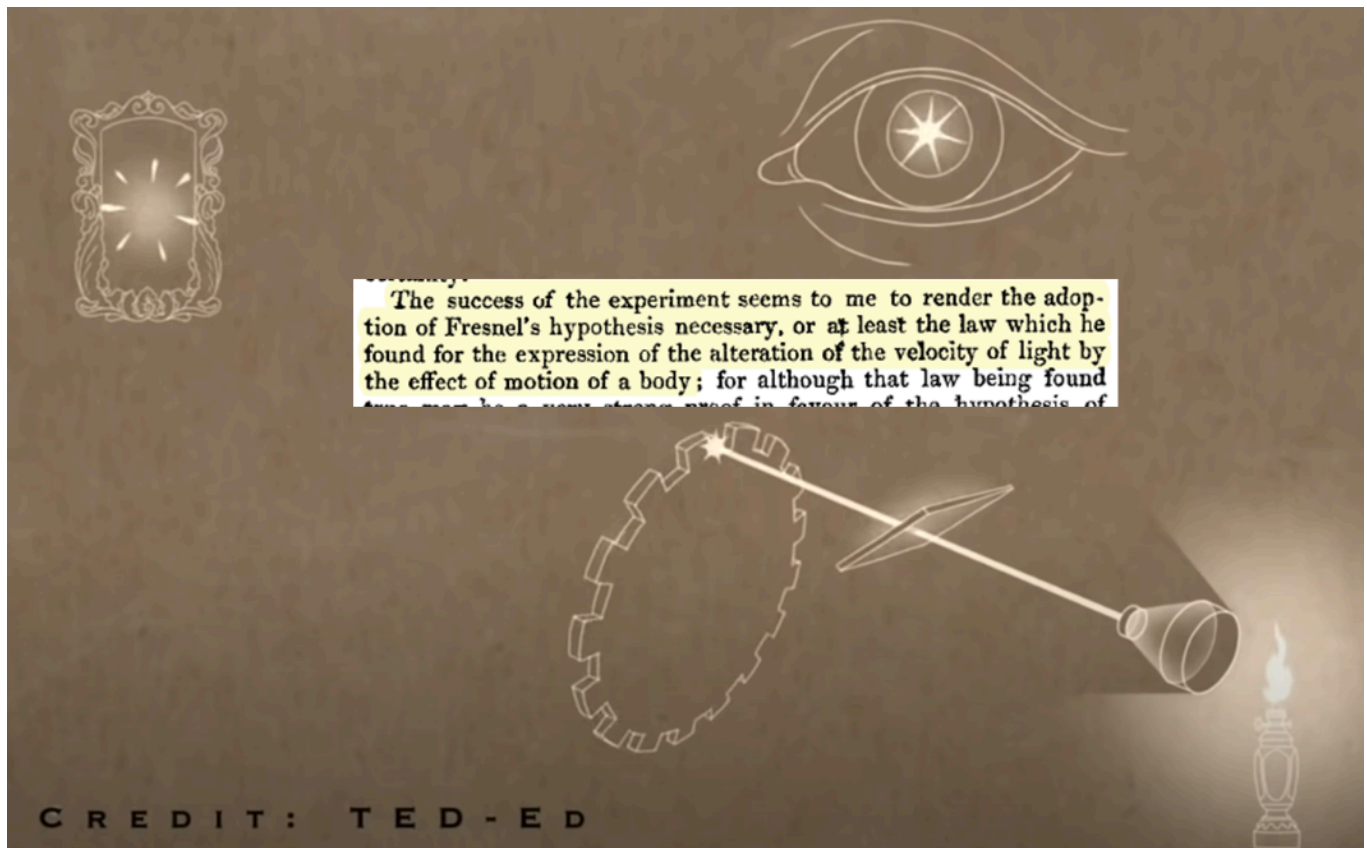
Why didn't Ein cite Voigt? B/c Doppler shift can be used to differentiate between inertial frames in relative motion to the Earth. It's the same equation.

- Shout-out to ItsBS
- Origins of the LT
- Derived in 1887 by W. Voigt
- The equations have always described oscillations in a medium
- Voigt's equations give you the transverse and longitudinal Doppler effect
- If you divide by the  $q$  factor in Voigt's equation, you'll get the equivalent Lorentz transform

Voigt equation for Doppler Shift and Lorentz Theory

Turns out they were always pref. frame equations

---



Notes:

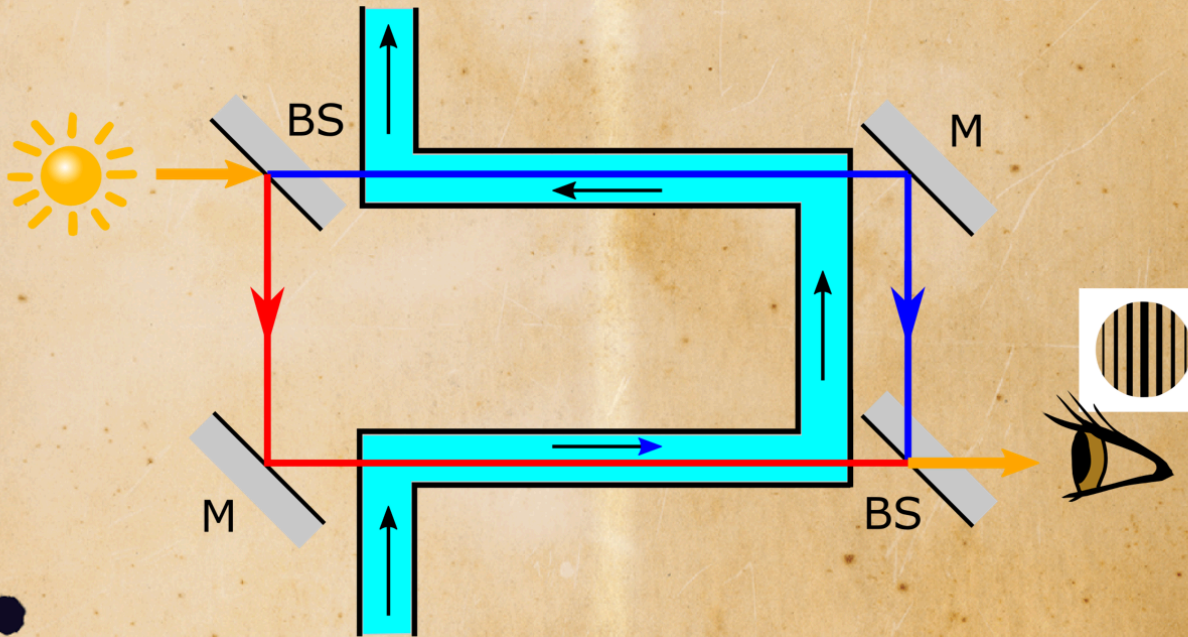
Fizeau, M. H. "Fizeau's Experiment: The Original Paper." Website, 1849.

---



# Fresnel Drag

$$1 - \frac{1}{n^2}$$

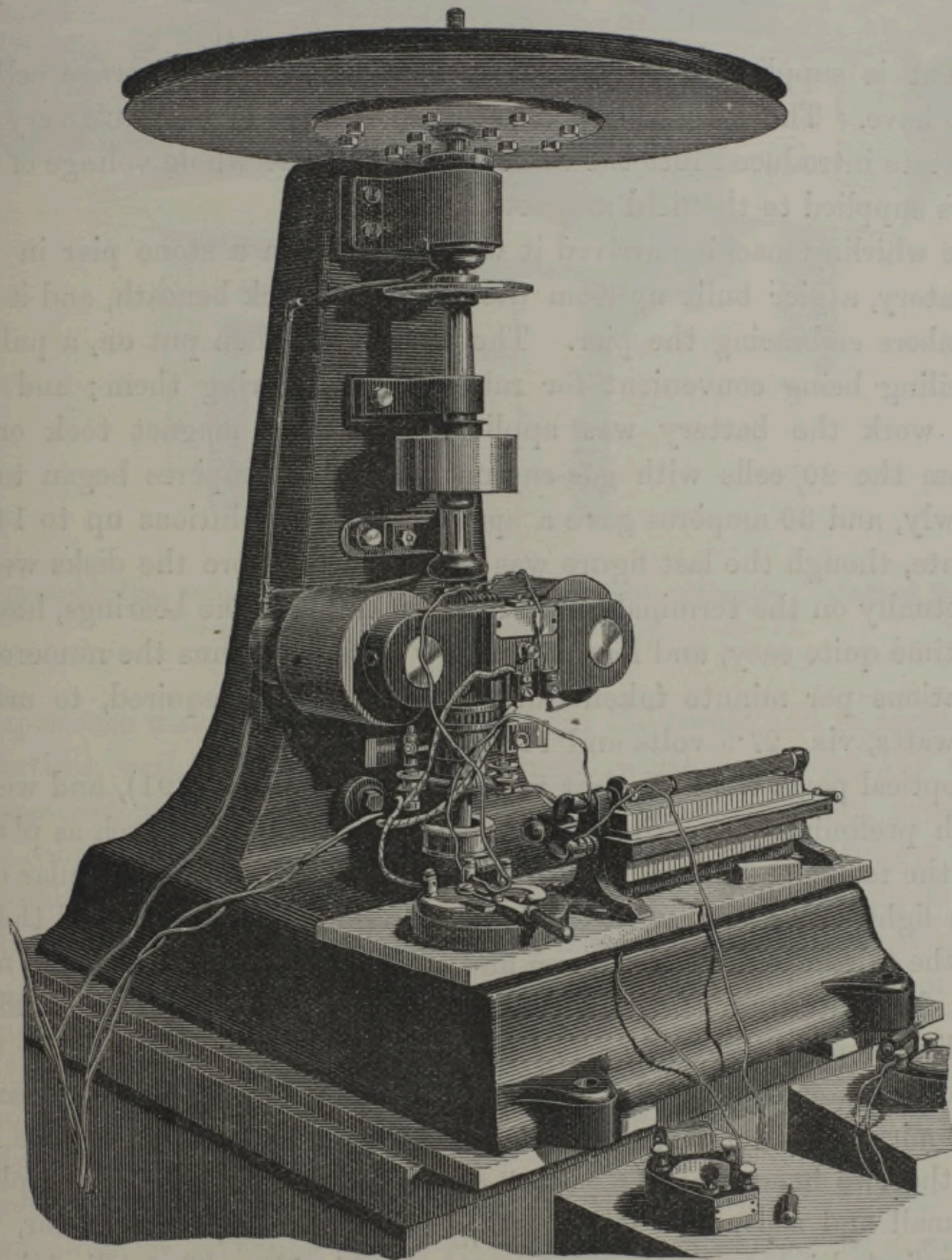


**44% Proportional Velocity!**

Notes:

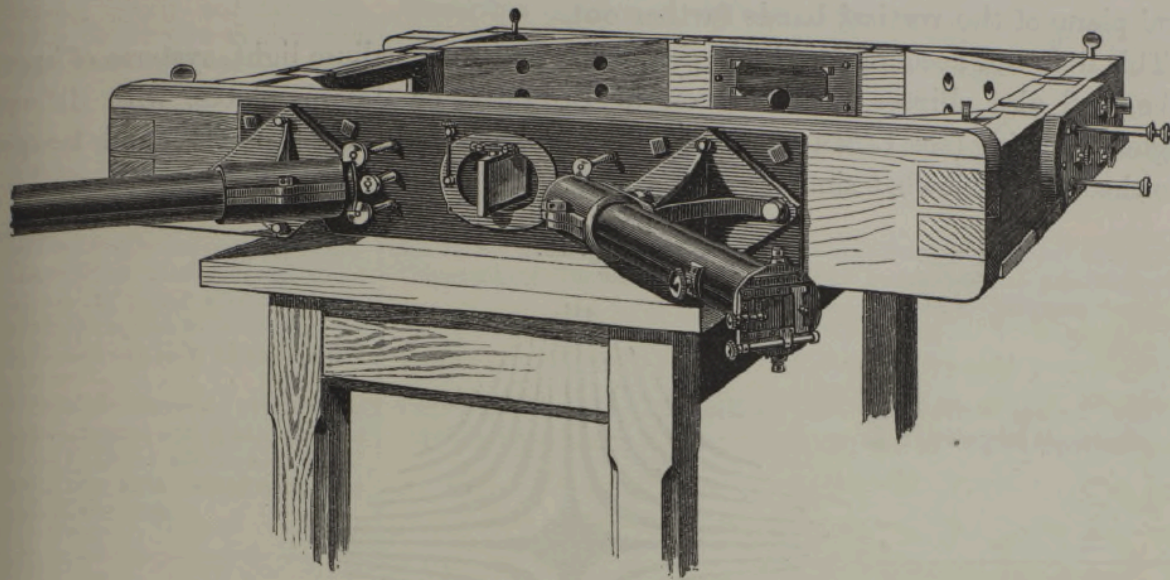
Fizeau, M. H. "On the Hypotheses Relating to the Luminous Aether, and an Experiment Which Appears to Demonstrate That the Motion of Bodies Alters the Velocity with Which Light Propagates Itself in Their Interior." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 2, no. 14 (1851): 568–73.

Fig. 9.



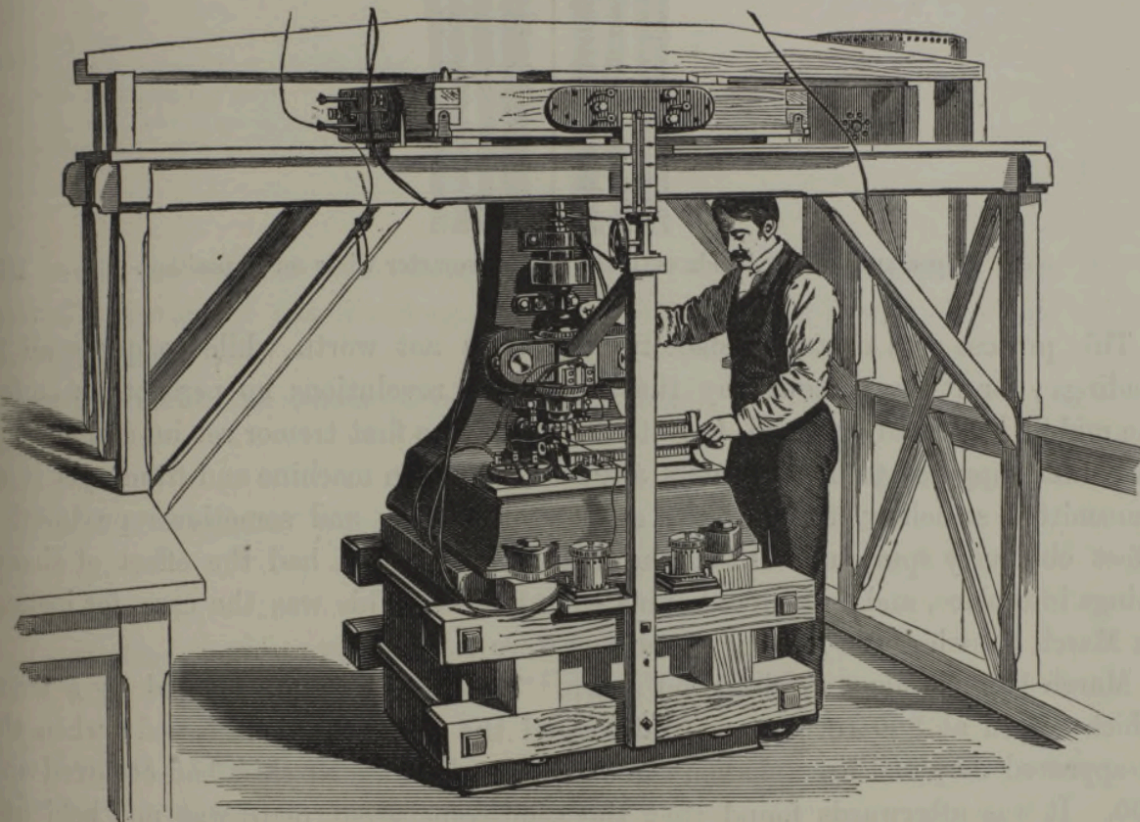
Whirling machine for ether experiment, with pair of steel disks, 1 yard in diameter. From a photograph taken during preliminary tests, before it was bolted down to stone pier. Full voltage is always supplied to the field magnets, variable resistance is in armature circuit only. The brass tube conducts away surplus oil. Drawings of the machine are given in Plate 32.





View of the optical frame, supporting the mirrors, telescope, and collimator: detached from its position round the steel disks, where it is shown in fig. 11.

Fig. 11.



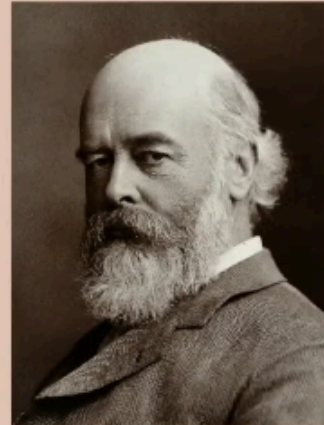
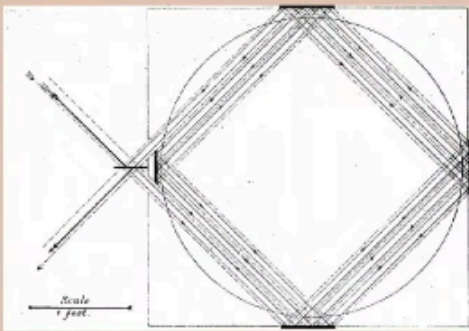
General view of the whirling machine, and independent support of optical apparatus, in action. The speed indicator is seen on top of front post, ammeter and voltmeter on framework. The long upper girders support the glazed drum which encloses the disks and secures the mirrors from the blast. Telescope, &c., are at back, not seen; boiler-plate screen for observer just visible. Everything independent of floor, and no contact between anything on central altar with anything on gallows framework.



- Lodge, F. Harress, Sagnac & Co.
- The need for GR

Lodge, Oliver J. "Aberration Problems. A Discussion Concerning the Motion of the Ether near the Earth, and Concerning the Connexion between Ether and Gross Matter; with Some New Experiments." Philosophical Transactions of the Royal Society of London. A 184 (1893): 727–804.

In 1892, Lodge performed a series of experiments examining whether the "light aether" would be entrained by the movement of a rotating mass.



Using an optical interferometer similar to that shown on the left, a maximum fringe shift of 2.25 fringes was expected for full entrainment of light with the rotating mass. Less than 1/20th of a fringe shift was detected.

*We seek to re-test this idea at significantly higher accuracy.*

Notes:

Shoutout to Plenum88

<https://www.youtube.com/watch?v=Elu11KCfSVI> 

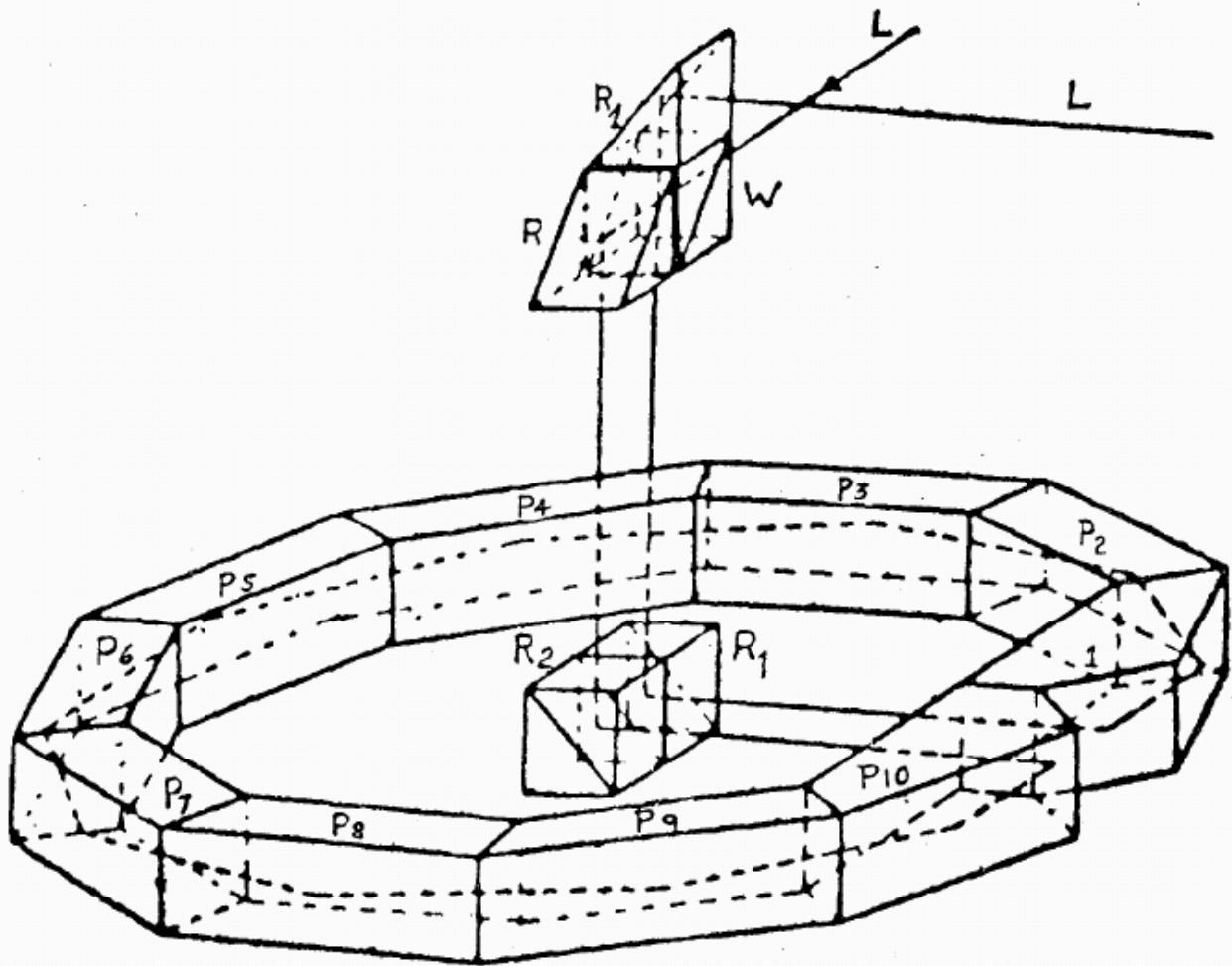
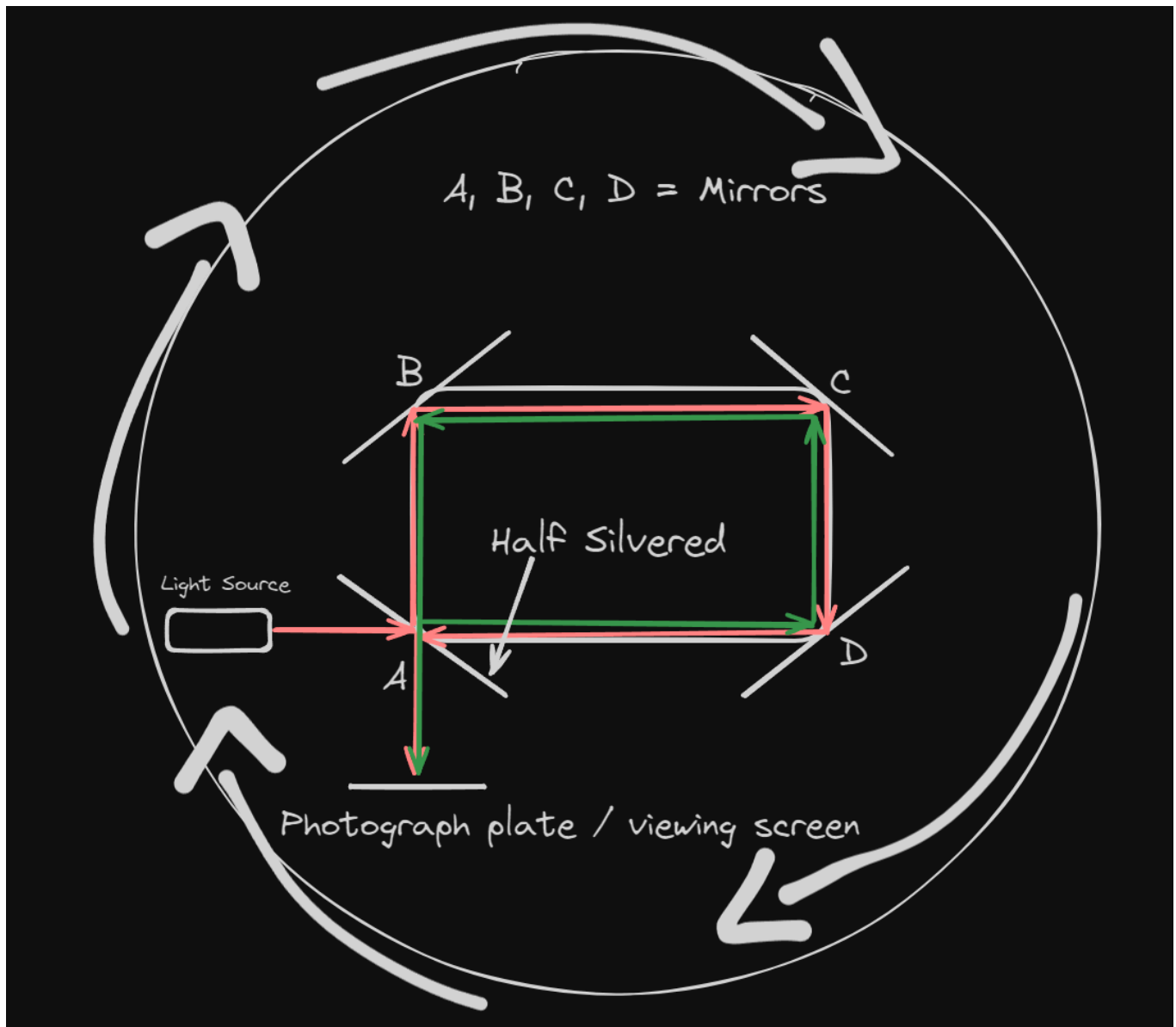


FIG. 3. Harress' ring interferometer.

Notes: Franz Harress 1911

- Close enough part II
- Laue 1920, showed that the Sagnac effect could be detected in Harress's numerical results.
- Harress apparently assumed that the fringe shift that is observed by rotating the interferometer is due solely to the "dragging" of the light by the moving glass medium.
- The effect would vanish when expression (2) vanishes, which is the case for free space  $n=1$ .
- Sagnac  $n=1$
- did tests with a series of ten prisms around the circumference of a disc; in this case short straight lines were also present. O



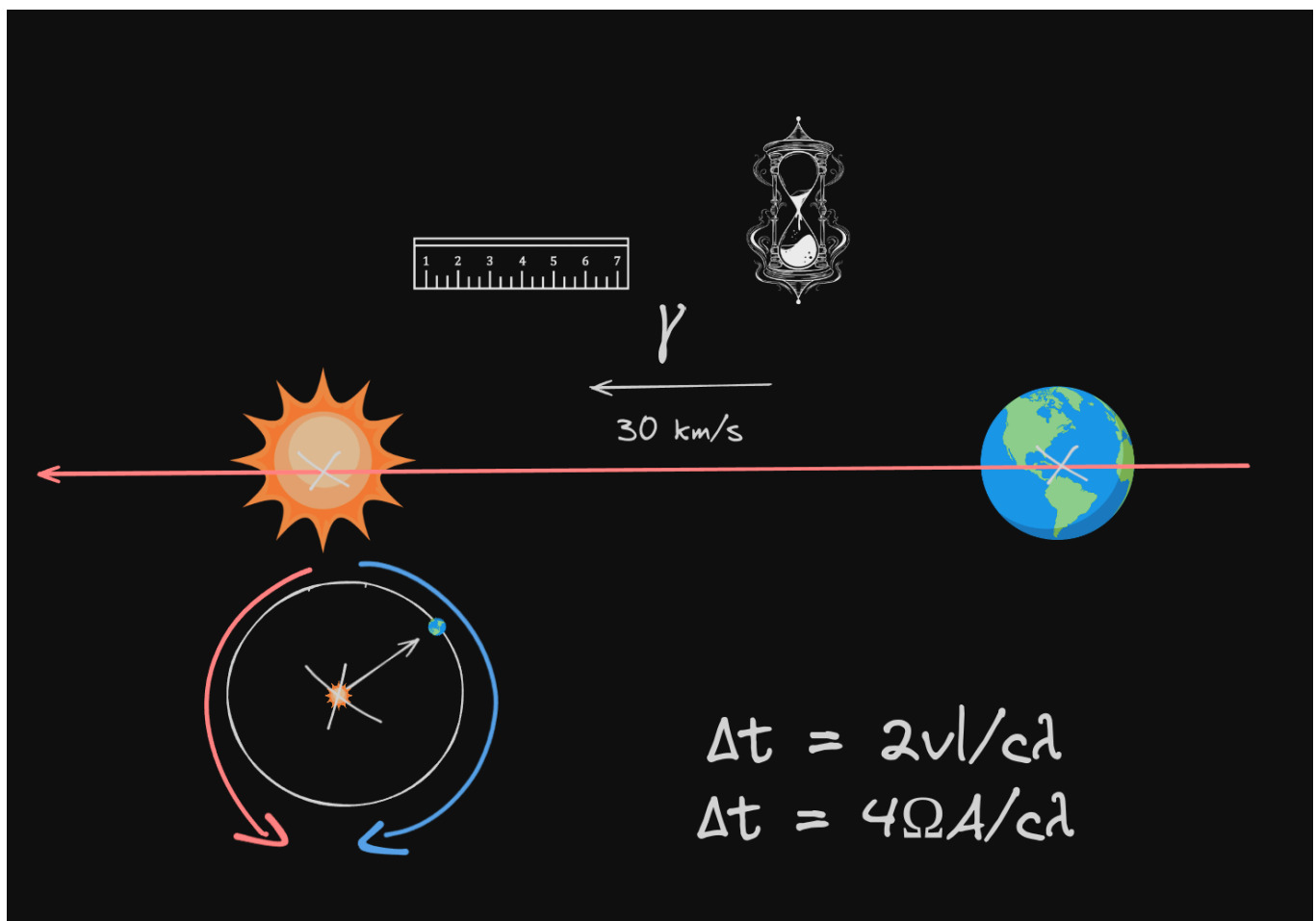
Notes:

this time the fringe is bigger than the refractive index

only the motion of the detector is significant and that that motion can be along a cord of the encompassing polygon-hence, properly addressed by the special theory, not the general theory.

- independent of the center of rotation and,
- shape of the area encompassed by the light beam.
- 1913

- absolute space
- optical vortex i.e. the material ether is independent of the air
- Fresnel drag requires a specific ratio to the refractive index
- mu and epsilon



Notes:

- Sagnac and GPS

- Sagnac, Georges. “The Optical Systems Variations in Motion and the Earth’s Translation,” 1911.

If you can measure Earth rotation wrt absolute space, you can measure the Earth around the sun using the sun as the fixed point of ref.

Orbits had to be changed again from circles to ellipses and this time to straight lines in free-fall

TABLE I. Dynamical equations of rectilinear and circular systems.

| Variable            | Rectilinear            | Circular                      | General                       |
|---------------------|------------------------|-------------------------------|-------------------------------|
| Position            | $x$                    | $\theta$                      | $p_1$                         |
| Velocity            | $v = \frac{dx}{dt}$    | $\omega = \frac{d\theta}{dt}$ | $p_2 = \frac{dp_1}{dt}$       |
| Acceleration        | $a = \frac{dv}{dt}$    | $\alpha = \frac{d\omega}{dt}$ | $p_3 = \frac{dp_2}{dt}$       |
| Mass/Inertia        | $M$                    | $I$                           | $p_4$                         |
| Newton’s second law | $F = ma$               | $\tau = I \alpha$             | $p_5 = p_4 p_3$               |
| Work                | $W = \int F dx$        | $W = \int \tau d\theta$       | $p_6 = \int p_5 dp_1$         |
| Kinetic energy      | $E = \frac{1}{2} mv^2$ | $E = \frac{1}{2} I \omega^2$  | $p_7 = \frac{1}{2} p_4 p_2^2$ |
|                     | .....                  | .....                         | .....                         |

Notes:

- Why/how motion was redefined by GR
- Suleiman, Ramzi. “Circular and Rectilinear Sagnac Effects Are Dynamically Equivalent and Contradictory to Special Relativity Theory.” *Physics Essays* 31, no. 2 (2018): 215–18.

$$1) v = v_0 + at$$

$$2) \Delta x = \left(\frac{v+v_0}{2}\right)t$$



$$3) \Delta x = v_0 t + \frac{1}{2} a t^2$$

$$4) v^2 = v_0^2 + 2a\Delta x$$

Notes: All describing d/t as a change in v.

- Where's the difference????!?!?!?
- How does the universe distinguish between rectilinear and angular velocity

To study the relationship between the motion of the fiber and the fiber orientation, we conducted an experiment in which the fiber zigzags and has an angle  $\theta$  with respect to the direction of fiber motion. Thus, for a fiber segment having an actual length of  $\Delta l$ , its effective length is  $\Delta l / \cos\theta$ , which is a projection of the fiber onto the motion direction. As shown in Fig. 2, our experiment demonstrates that the effective length contributes the phase difference, not the actual length; therefore, the phase difference  $\Delta\phi$  is not  $4\pi v \Delta l / c\lambda$ , but

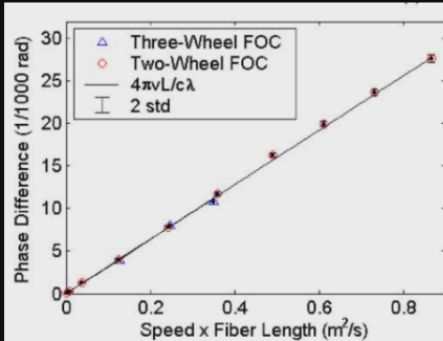
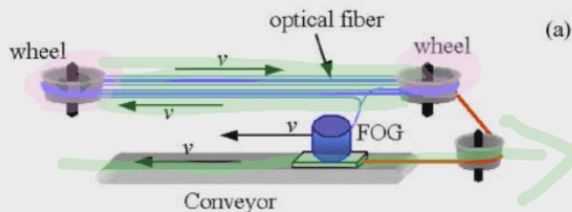
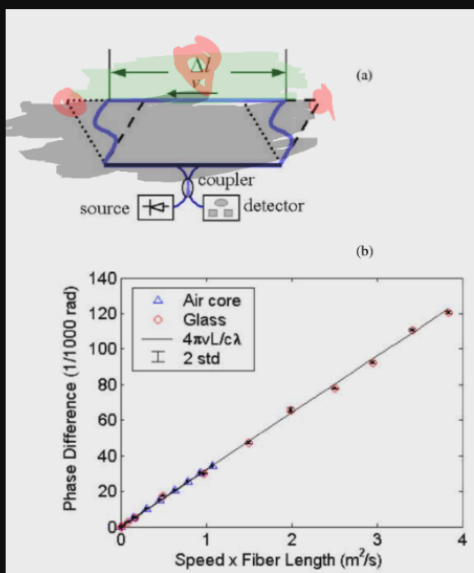


FIG. 1 Experiment for detecting the phase difference of two counterpropagating light beams in a moving fiber loop. (a) Experimental setup. The fiber loop is driven by the conveyor at a velocity  $v$ . The conveyor has a length of 1.5 m and can move from 0.001 to 0.25 m/s. The diameters of the wheels are 0.3 m. The FOG consists of a 1310-nm superluminescent light-emitting diode as the light source and a phase difference detector that has an output rate of 1162.6 mV per rad. (b) Phase differences of two counterpropagating beams in a moving air-core fiber.

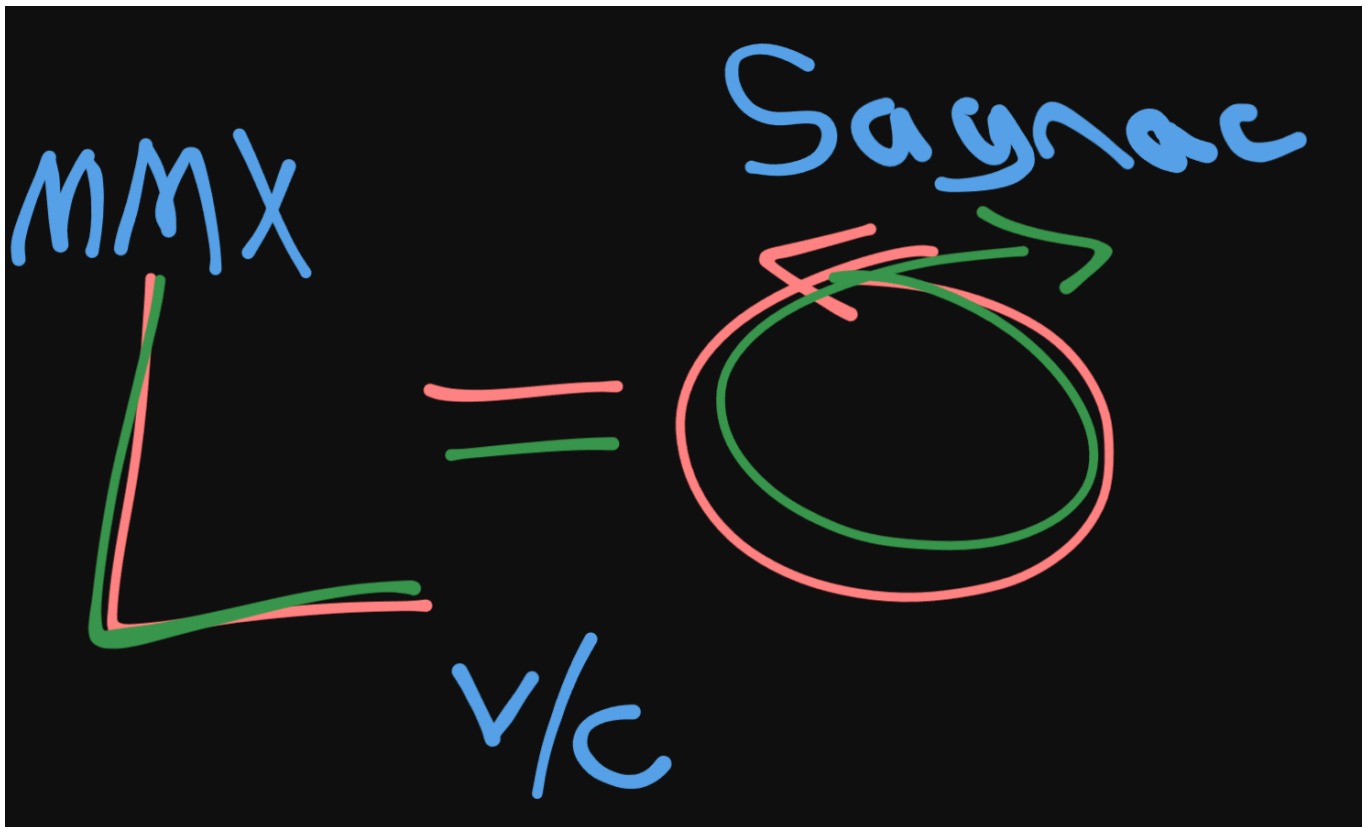


According to our experiments, we can draw a conclusion about the generalized Sagnac effect that in a moving fiber loop or waveguide, a segment  $\Delta l$  with a velocity  $v$  contributes  $\Delta\phi = 4\pi v \cdot \Delta l / c\lambda$  to the total phase difference between two counterpropagating beams in the loop. The contribution  $\Delta\phi$  is independent of the refractive index of the waveguide, and the motion of the segment

Notes:

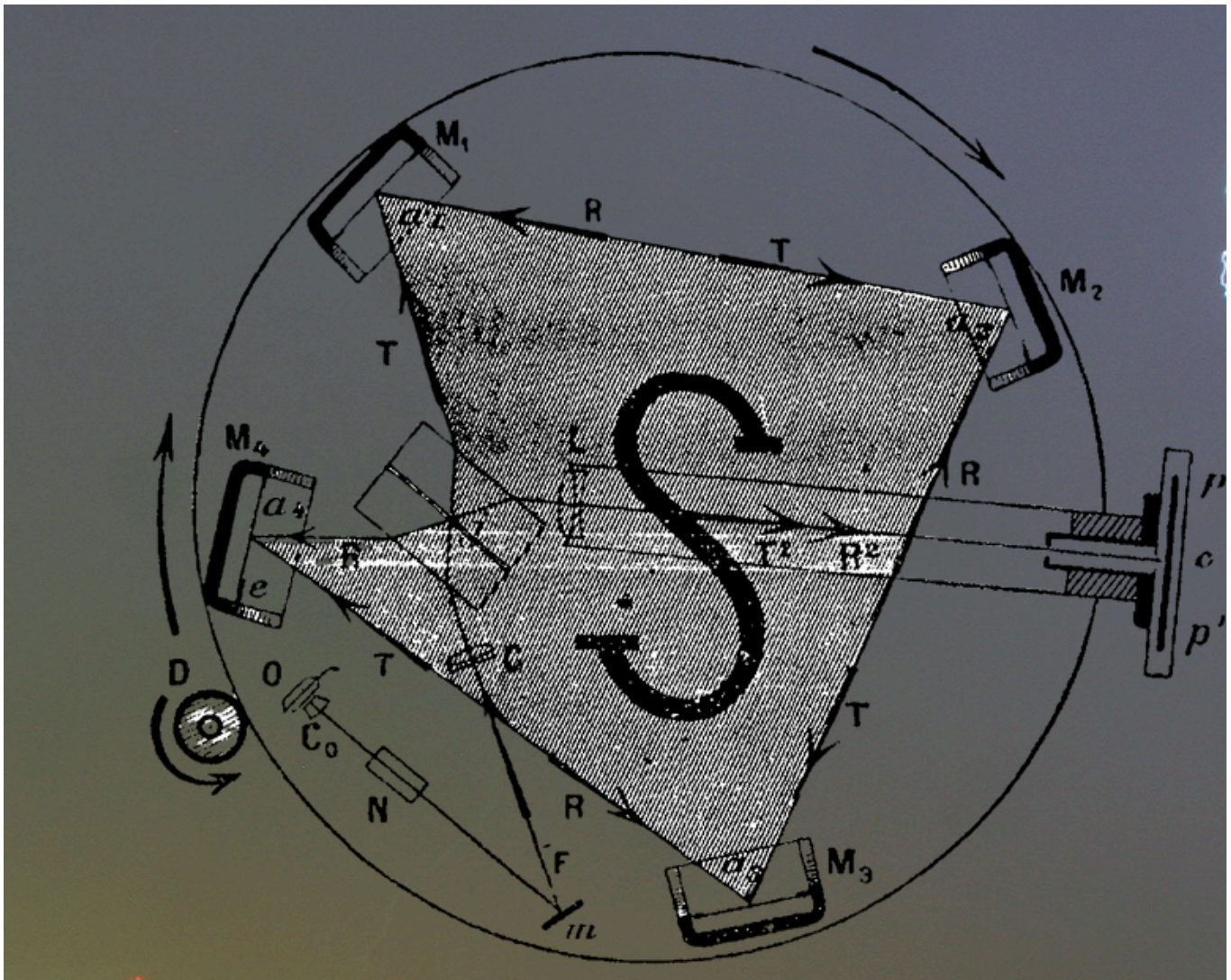
Equiv. Experimentally verified by Ruyong Wang in 2004

- None of the optical path configurations matter, so long as they make a closed loop polygon



Notes:

- Wang conclusion ; Experimental fact



Notes:

- The very definition of a closed polygonal circuit in uniform translational motion.
- 1913
- Fringes independent of symmetry wrt central axis of rotation
- SR dependent on symmetry to invoke cylindrical coordinate system transformations into the clock frame
- Dynamic falsification of Lorentz symmetry Kinematics as a dynamic explanation



## B. Remarks

A number of comprehensive articles [14, 25–28] have described various aspects of the Sagnac effect and have also undertaken to elucidate the conceptual difficulties that seem to be encountered in its interpretation. Various authors have derived the Sagnac phase shift in a number of ways: by optical analogy [13], general relativity considerations [10, 29, 30], special relativity analyses [28, 31–35], the WKB approximation [15], the Doppler effect of moving media in an inertial frame [36], a classical kinematical derivation [22, 37–39], dynamical analysis in a noninertial frame [40, 41], by analogy with the Aharonov-Bohm effect [42], by extension of the hypothesis of locality [43], by adiabatic invariance [44], using ether concepts [45], and in other ways. This great variety (if not disparity) in the derivation of the Sagnac phase shift constitutes one of the several controversies (recounted, e.g., in [31, 46, 47]) that have been surrounding the Sagnac effect since the earliest days of studying interferences in rotating frames of reference.

The classical kinematical derivation, as it has been used by many authors (see above), has the advantage of yielding the correct first-order result in a very simple and intuitive way. Its starting point is a consideration that applies to any type of waves, and it seems entirely classical. Consider a circular path with radius  $R$ .

Notes:

- 1993
- Since the dawn of time men have attempted to explain the Sagnac effect as a Relativistic effect
- Notably, 1917 Paul Langevin GR story

- Later abandoned in modern INS manuals
- 

obtain the observed effect. In Post's (1967, 486) words:

A [standard free-space] d'Alembertian wave equation can in no way whatever, explain the nonreciprocal asymmetry between the clockwise and counterclockwise beams observed in the Sagnac effect, because a nonreciprocity requires the presence of mixed space-time derivatives ( $\partial/\partial t \partial x$ ) in the wave equation. Thus in order to account for the asymmetry one has to assume that either the Gaussian field identification [ $E=D$  and  $B=H$ ] does not hold in a rotating frame or that the Maxwell equations are affected by rotation.

Or, in lieu of either of Post's options, one can reject the special theory.

Notes:

- Separate the EM process into respective fields,
  - all fields wrt "free-space"
  - Make EM processes dependent on the rotational speed of free-space (ether)
  - Goes to say that he's deriving his effects based on the mechanism of centrifugal potential akin to gravitational potential as the mechanism to explain a first-order Sagnac measurement
  - Time difference caused by centrifugal potential
  - Incompatible mechanism w/ Thomas precession; acceleration physically causing the variance
  - Can't use the same Lorentz transforms with different causal mechanism
  - Extend Post's derivation out to a radius of the Earth and sun and it fails
-

A search of the literature reveals some claims that the Sagnac effect can be explained by the general theory. An article by Ashtekar and Magnon (1975) purports to give such an explanation. However, the argument is nearly impossible to follow and, most important, fails to show why the same argument would not give a similar effect for the earth's orbital rotation around the sun—an effect which is contradicted by the Michelson-Morley experiment.

Notes:

Ashtekar & Moagnon - Inconsistent explanation with MMX & MGP

---

An article by Alley et al. (1988, 280) gives a derivation of the metric on a rotating body, using the general theory. They conclude that the speed of light would be different eastward than westward; but they go on to say:

It is not clear whether we should actually observe this difference, however, since the metric of Eq. (15) seems to assume that the observer is located at the center of rotation.

Notes:

- if wrt to central axis will the observer match the "proper time/distance" of the moving observer?
  - If  $c = c$  in an inertial frame, then there can be no measurement for the observer (recorder) on the rotating earth
  - Not sure if a lab lad would measure it
  - Invoking absolute space for the the symmetrical point of view
-



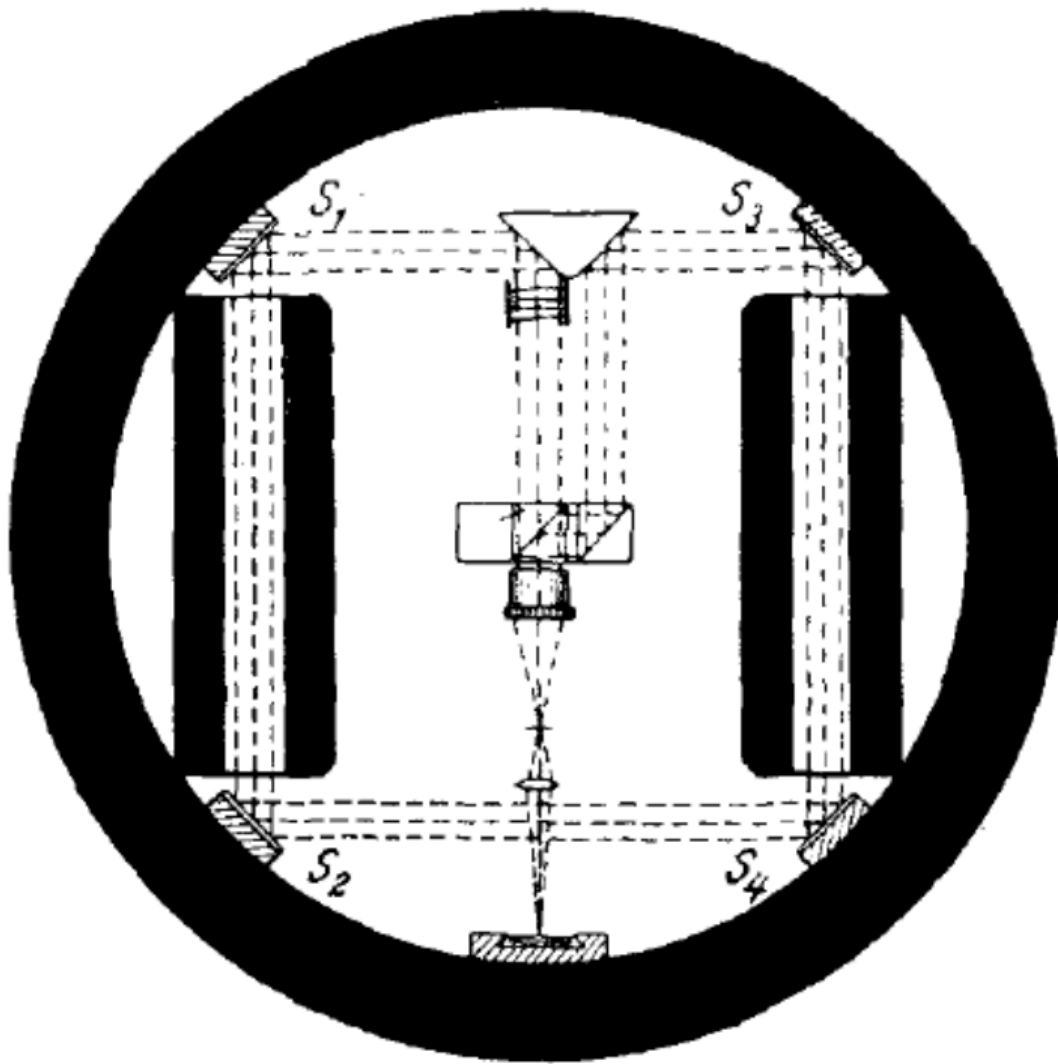


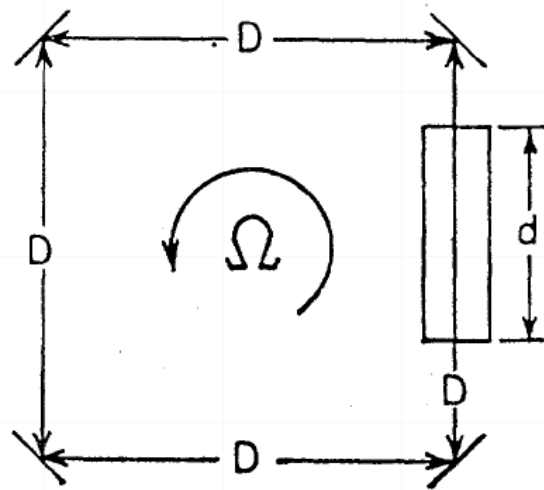
Fig. 1

Notes:

- symmetrical polygon in uniform translator motion -> linear segments
- 1927
- Linear segments in uniform translator motion wrt **WHAT?** (Lil Jon)

For example, considering the data in the Pogany test (8), where the rim of the disc was moving with a velocity of 25 m/s, the ratio  $dt_s \div dt_R$  is about  $1.5 \times 10^7$ . Any attempt to explain the Sagnac as a Relativistic effect is thus useless, as it is smaller by a factor of  $10^7$ .

FIG. 10. Square ring laser with comoving medium in the beam path.



## F. Consistency Checks

To be consistent with the principle of relativity one has to demand that the Sagnac interferometer and the ring laser cannot lead to a fringe shift or a beat frequency if the equipment is in uniform translational motion. An inspection of formulas (46) and (51) shows that it is necessary and sufficient to require that

Notes:

Post, E. J. "Sagnac Effect." *Reviews of Modern Physics* 39, no. 2 (April 1, 1967): 475–93. <https://doi.org/10.1103/RevModPhys.39.475>

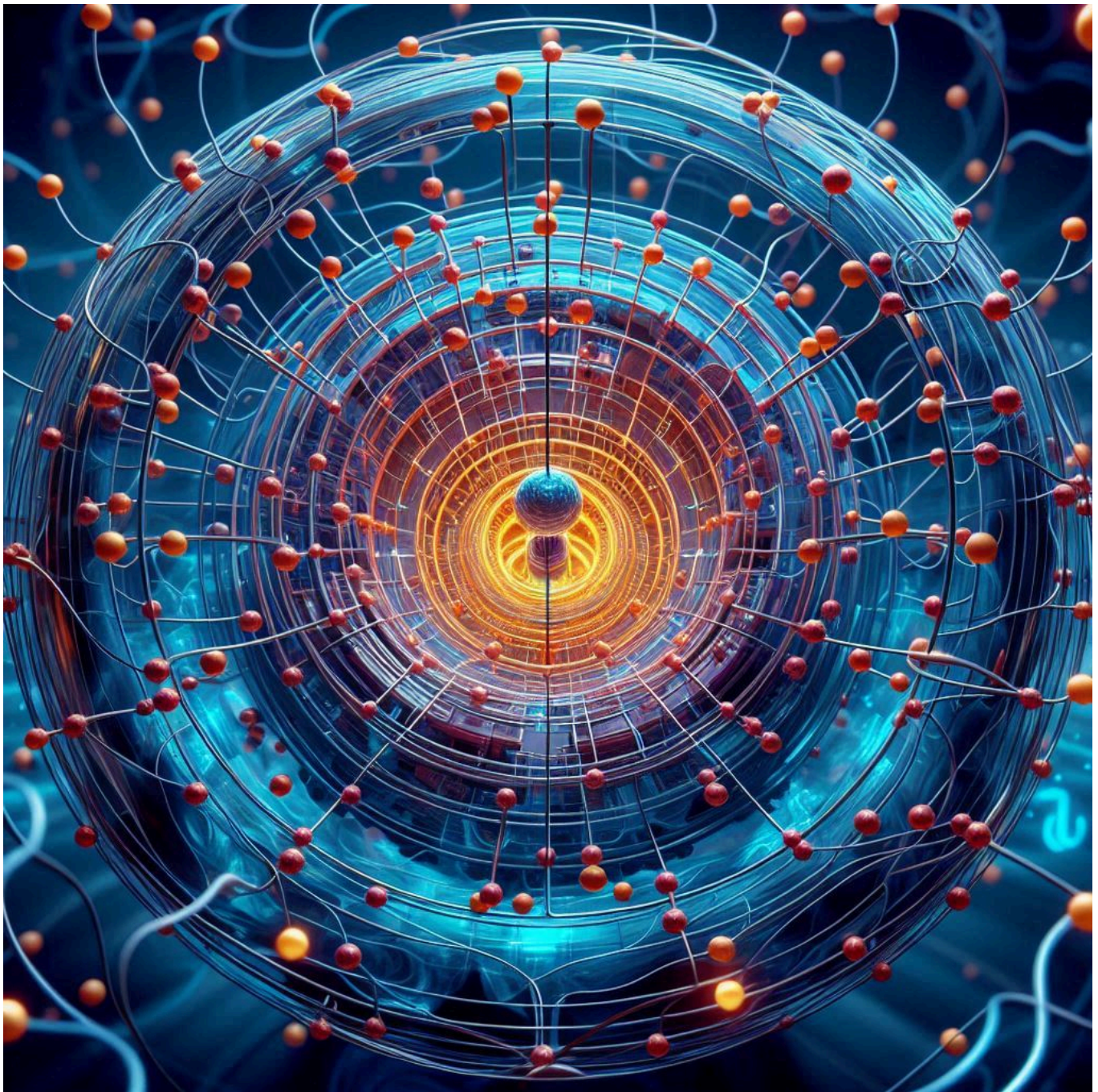
But Born is clearly wrong. As Friedman (1983) shows, the general theory has incorporated into it the infinitesimal structure of the special theory. Thus, no matter which theory is called upon, the procedure for handling accelerations is to process them such that the instantaneous velocity is used in the appropriate Lorentz transformation. Goldstein (1980) clearly spells out the method for handling accelerations:

Consider a particle moving in the laboratory system with a velocity  $v$  that is not constant. Since the system in which the particle is at rest is accelerated with respect to the laboratory, the two systems should not be connected by a Lorentz transformation. We can circumvent this difficulty by a frequently used stratagem (elevated by some to the status of an additional postulate of relativity). We imagine an infinity of inertial systems moving uniformly relative to the laboratory system, one of which instantaneously matches the velocity of the particle. The particle is thus instantaneously at rest in an inertial system that can be connected to the laboratory system by a Lorentz transformation. It is assumed that this Lorentz transformation will also describe the properties of the particle and its true rest system as seen from the laboratory system.

Notes:

- SR procedure method for handling in uniform rotation: Lorentz boost
  - "imagine" an infinity of inertial systems to complete the loop
  - WRT the LAB FRAME
  - The Lorentz Triangle => back to the lab frame (again)
-

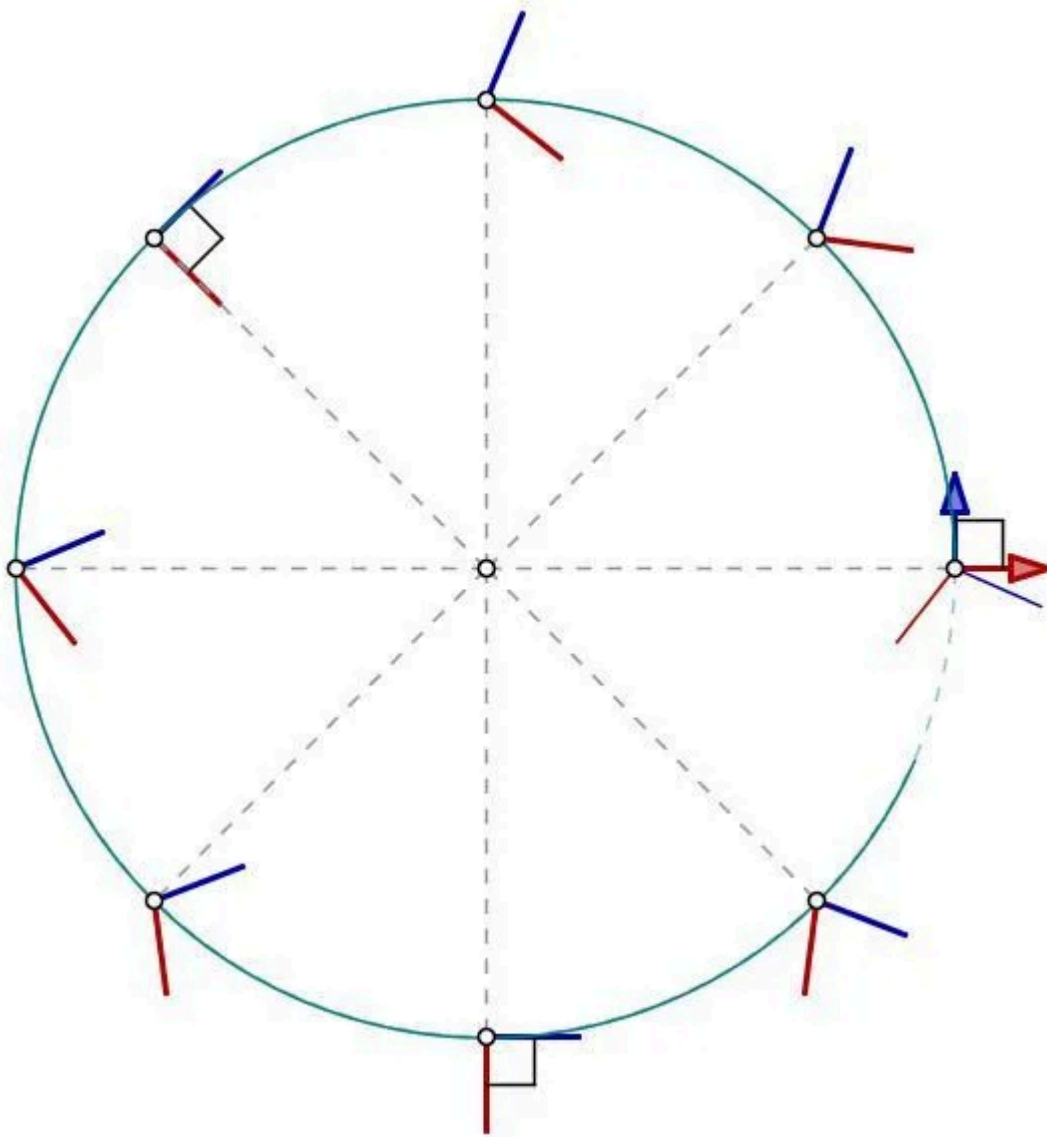




Notes:

- Thomas precession
- Derived from a LT to explain the anomalous precession of the spin of an orbiting electron in an atom
- Mechanism -> Acceleration around nucleus
- Post tried to claim his derivation leads to Thomas precession
- Ron math checked says no Dice

- Proposed mechanism inconsistent w/ SR
- Thomas showed that two successive Lorentz boosts used to account for radial acceleration are equivalent to one Lorentz transformation together with a coordinate rotation.
- two world line inversions wrt to the central axis is equivalent to one linear Lorentz transform
- Yet none of these can derive the Sagnac effect as a Relativistic effect
- 



Notes:



- What a Lorentz boost looks like
- two world line inversions wrt to the central axis is equivalent to one linear Lorentz transform

$$dt = 4A\omega/c^2$$

Notes:

## • Thought experiment

- Suppose a disc of a radius of 1km

It was shown in Kelly (1995) that the Theory of Special Relativity has no relevance in trying to explain the Sagnac effect. As seen earlier, the speeds involved in a Sagnac test are so low (13m/s on a 1m radius disc to yield a shift of one fringe) that no relativity effect could arise. In any case the relativity effect would be too small by a factor of 500b on a disc of 1 km radius giving the same fringe shift as got by Sagnac.

AG Kelly Non-relativistic effect

- no boost or xform can save explain Sagnac

- 

Surely, a hero will emerge and explain the Sagnac effect as a consequence of Relativity Theory, Special or General

Notes:

uniform rectilinear motion with respect to  $K$  (in accordance with the law of Galilei) is executing an accelerated and in general curvilinear motion with respect to the accelerated reference-body  $K'$  (chest). This acceleration or curvature corresponds to the influence on the moving body of the gravitational field prevailing relatively to  $K'$ . It is known that a gravitational field influences the movement of bodies in this way, so that our consideration supplies us with nothing essentially new.

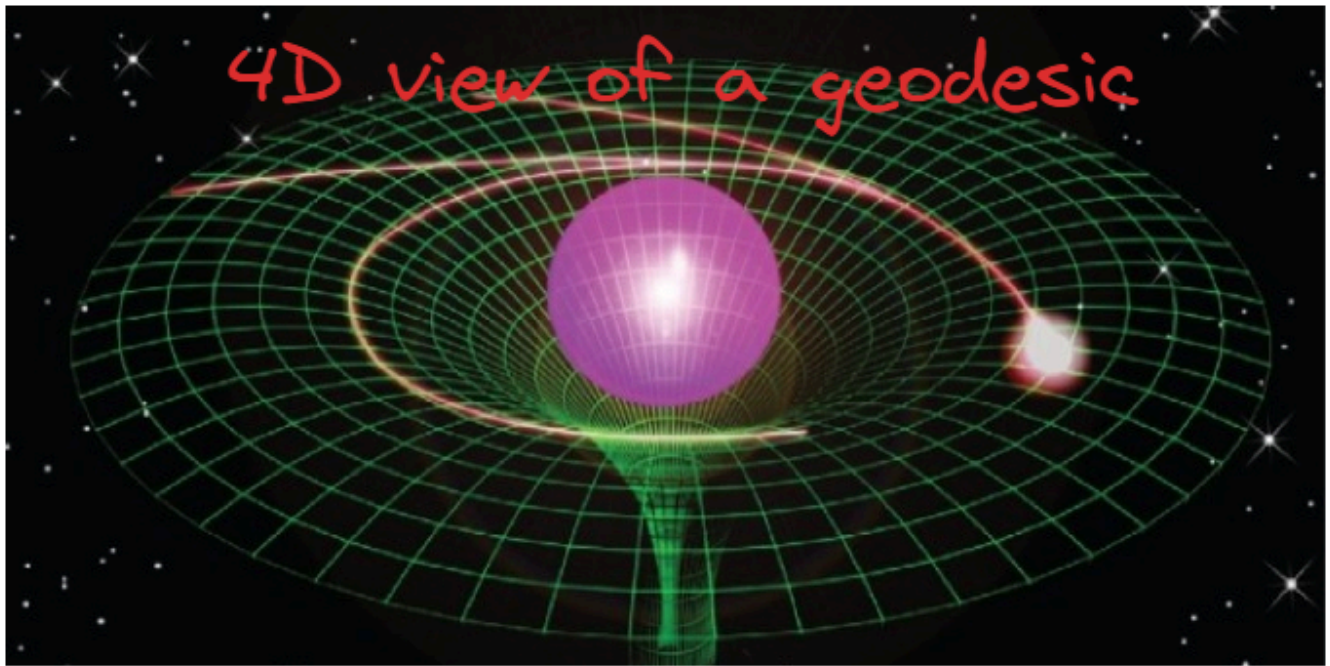
However, we obtain a new result of fundamental importance when we carry out the analogous consideration for a ray of light. With respect to the Galileian reference-body  $K$ , such a ray of light is transmitted rectilinearly with the velocity  $c$ . It can easily be shown that the path of the same ray of light is no longer a straight line when we consider it with reference to the accelerated chest (reference-body  $K'$ ). From this we conclude, that, in general, rays of light are propagated curvilinearly in gravitational fields. In two respects this result is of great importance.

Notes:

Redefines rectilinear to mean CURVED

Einstein, Albert. "On the Special and General Theory of Relativity." CPAE (English Translation) 6 (1917): 247–420.

---



Notes:

- What a geodesic is
  - why orbits were changed to be even more abstract
-

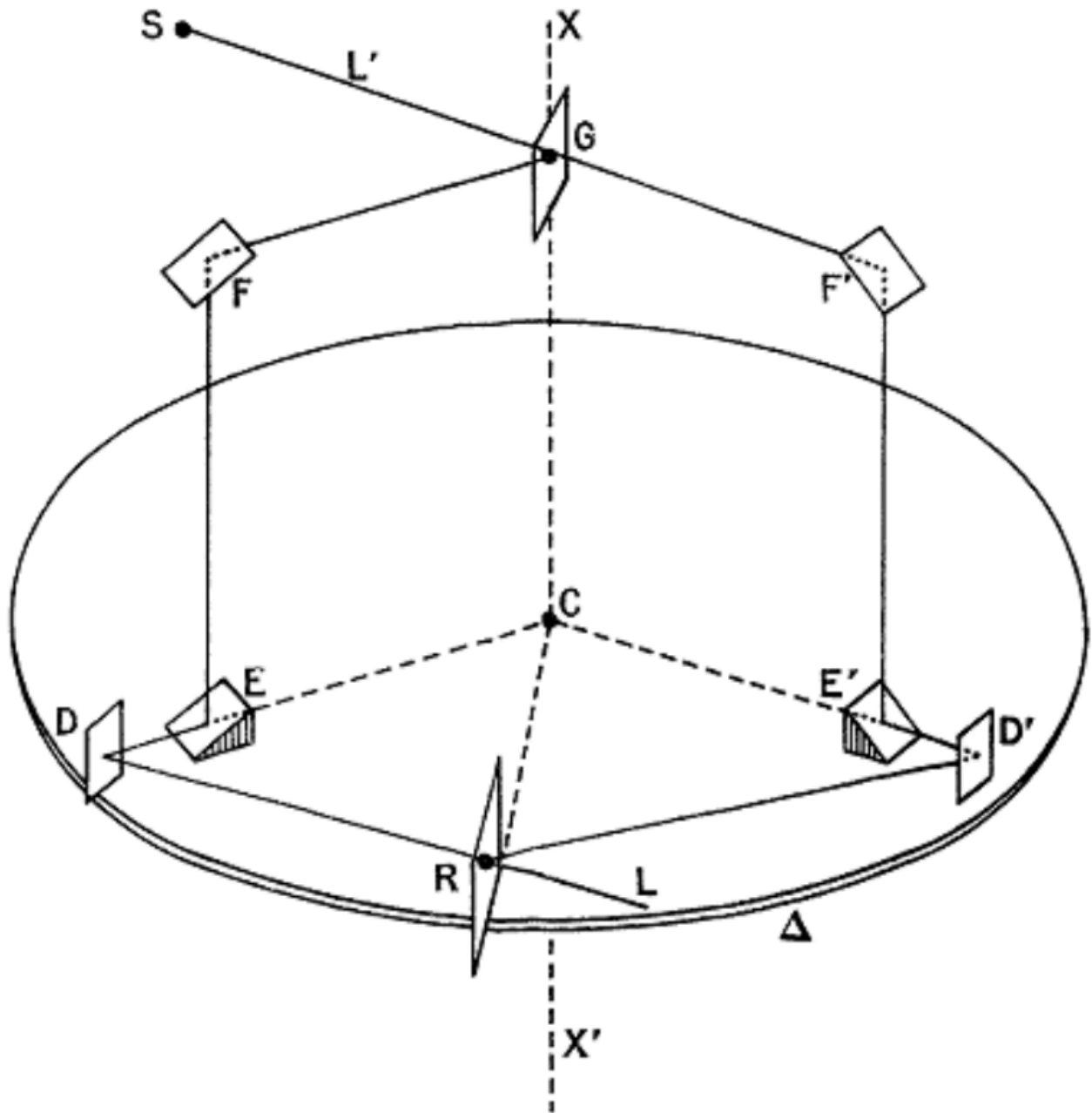
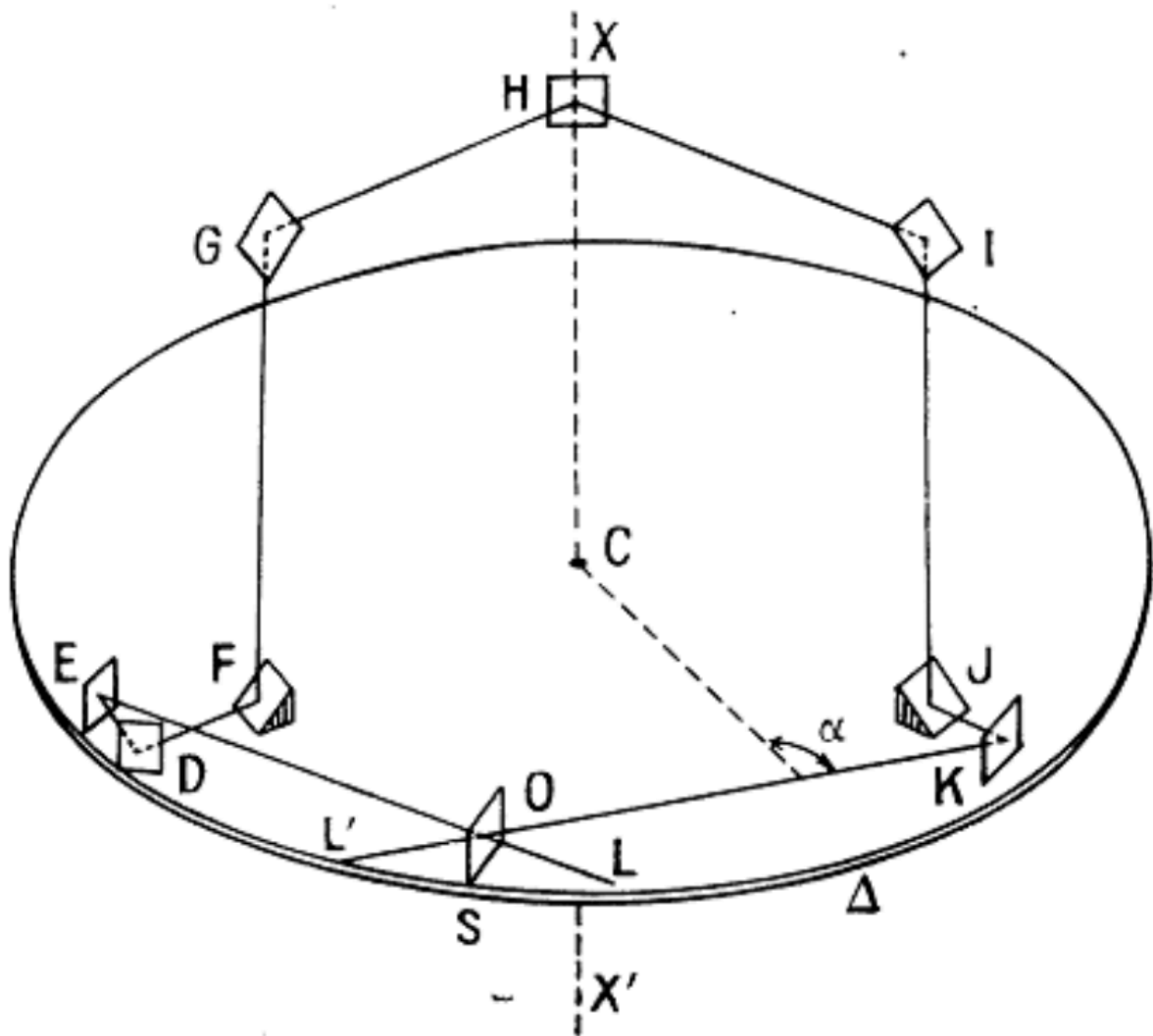


Fig. 5.

Notes: Dufour and Prunier

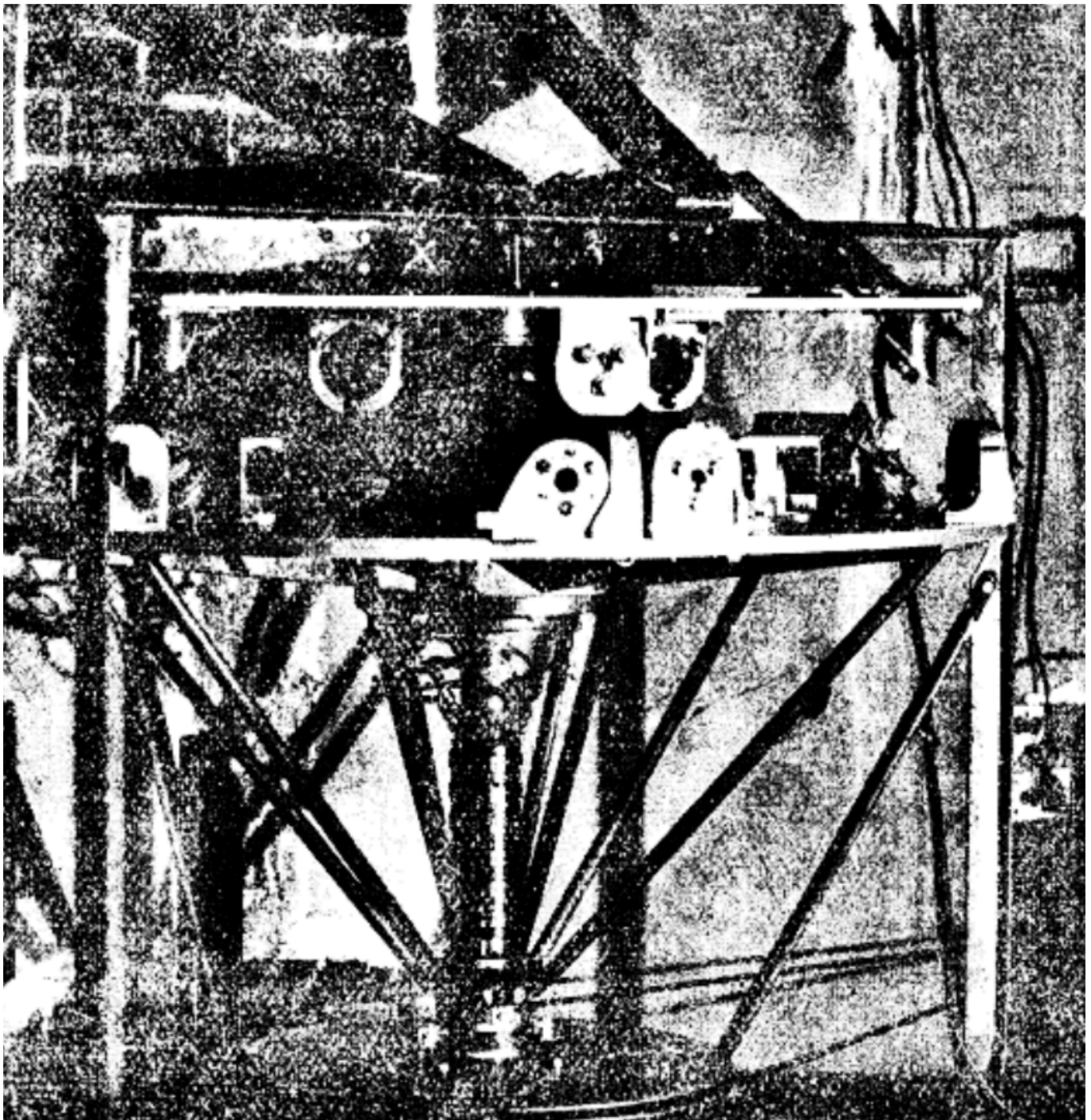
- One last GR check before we dip



Notes:

- Actual pathing





Notes:

- 10cm
  - Optical vortex generated by the device caused retardation
-

By introducing these numerical values into the expression of the fringe shifts  $\delta$ , one finds with  $\lambda = 0.56 \text{ } \mu\text{m}$ , for the two directions of rotation and for an angular velocity of 1 turn/sec,

$$\delta = \frac{16 - A'}{e\lambda} = 0.053 \text{ in fringes} \quad (\text{according to the classical theory})$$

$$\delta = \frac{16 - A'}{e\lambda} = 0.005 \text{ in fringes} \quad (\text{according to the relativistic theory});$$

that is to say a value that is approximately ten times smaller, according to this last theory than according to the preceding one.

The relativistic theory thus seems to be in complete dissention with the classical theory and also with the result provided by this experiment. But given that, as the note of Mr. Langevin appeared to allow the value to be reported higher, we have considered that the center where the theoretical relativist must be presumed placed can be arbitrarily selected. The relativistic theory is found contrary to agreement with the classical theory and the experiment if this center is obligatorily colinear with the center of rotation of the disc, the only point on the disc which can be the permanent origin of Galilean axes not subjected to the rotational movement of the unit. This is despite the explanation that Mr. Langevin said to us, and which he arrived at after having been informed of the result of our experiments.

Notes:

- Requires a preferred frame
- GR/SR cannot even attempt to give a non-answer in second-order terms by setting up a "geometrically convenient" transformation
- From their geometrically convenient spot, they now they setup for a first-order  $v/c$  as a timing difference between an observer at the center and at the rim in constant motion.
- It cannot deal answer the effect without a pref. frame.

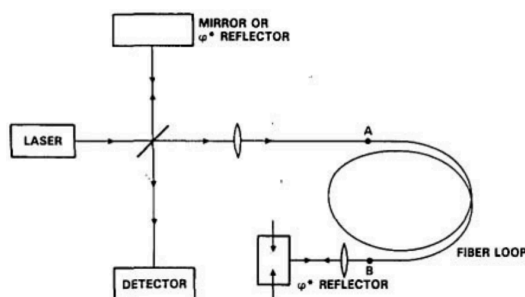


Fig. 1. Schematic drawing of the phase-conjugate fiber-optic gyro.

The fiber coil is rotated with the rest of the setup remaining fixed at various rotation rates [first clockwise (CW), then

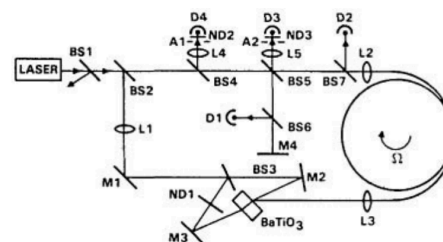
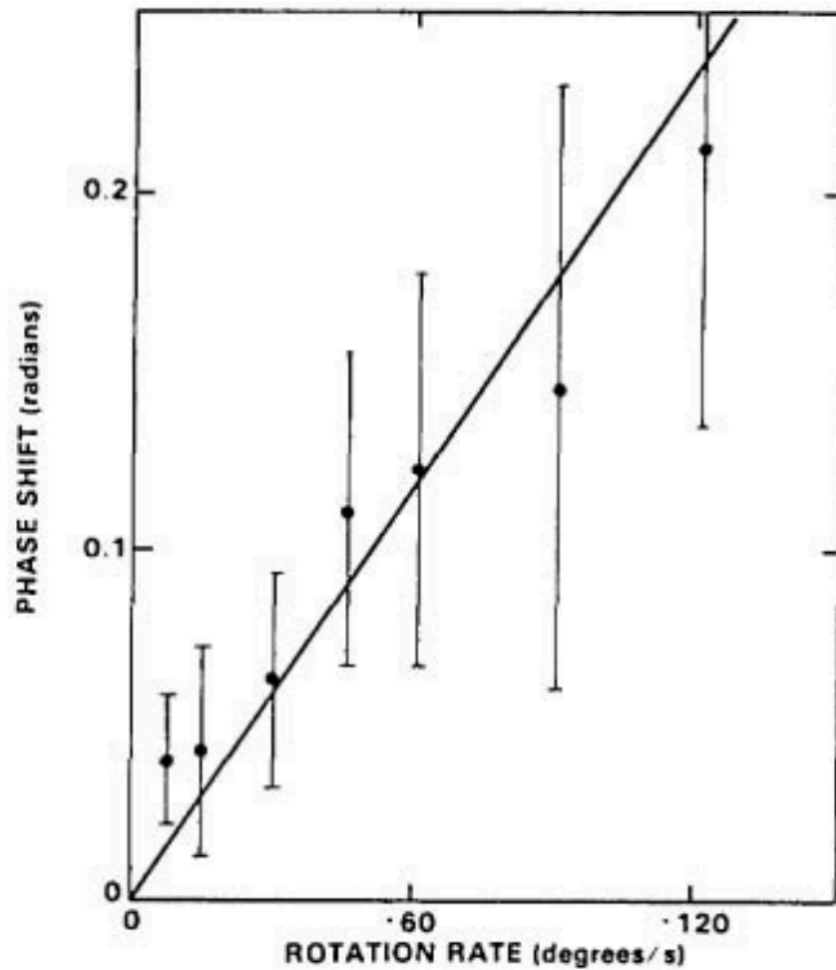


Fig. 2. Experimental setup of the phase-conjugate fiber-optic gyro.

Notes:

Yeh, Pochi, Ian McMichael, and Monte Khoshnevisan. "Phase-Conjugate Fiber-Optic Gyro." *Applied Optics* 25 (01 1986): 1029–30.  
<https://doi.org/10.1364/AO.25.001029> .

---



**Fig. 3.** Measured phase shift as a function of applied rotation rate.

Notes:

---

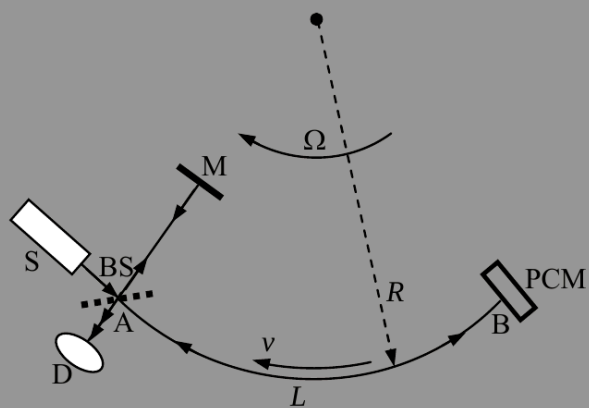


Fig. 5. The phase-conjugate Sagnac experiment.

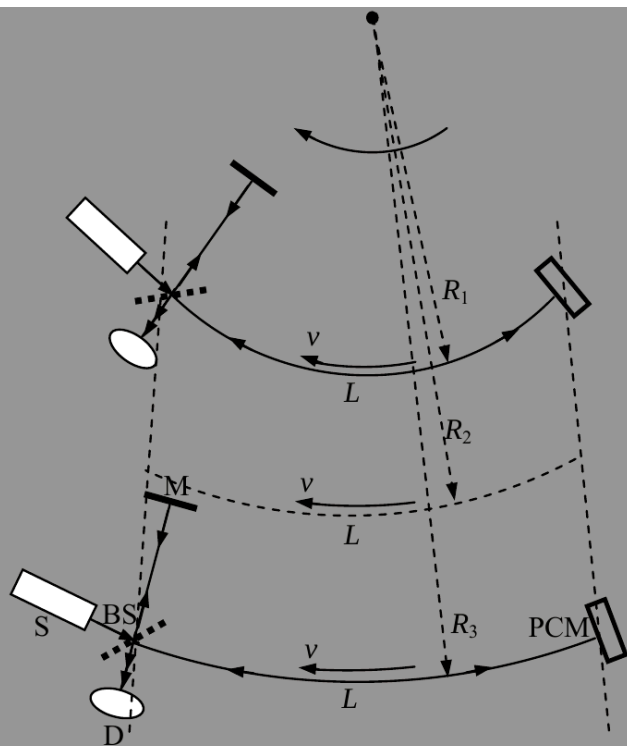


Fig. 6. The phase-conjugate Sagnac experiment with an increasingly larger radius of the rotation.

Notes:

Wang, Ruyong, Yi Zheng, and Aiping Yao. "Test of the One-Way Speed of Light and the First-Order Experiment of Special Relativity Using Phase-Conjugate Interferometers," 24 2006.

Image

Notes:

- Uniform translatory motion falsified by Sagnac & Co. (1910-2004)
- GR 1915 to explain uniform translatory motion as acceleration
- At this point it was starting to become more and more experimentally obvious that SR wasn't true and it would lead back to the Copernican principle being falsified by conclusively by MMX



Keating experiment indicates. The GPS tracking-station clocks verify this direct effect of the gravitational potential upon the clock rate. The tracking-station clocks require adjustment for their height above sea level. Interestingly, they do not require adjustment for their latitude. The oblateness of the Earth due to its spin rate is such that the effect of the extra gravitational potential (greater equatorial radius) upon clocks at the equator is precisely cancelled by the greater equatorial spin velocity effect upon the clocks.

Notes:

- Missing GPS Corrections
- Hatch, R. R. "Modified Lorentz Ether Theory" Infinite Energy 39 (2001): 24–28.

define coordinate time as on the rotating geoid.  
Both bodies name three corrections as "*relativistic*"; these are the velocity effect correction calculated under SR (for use when transporting a clock), the correction for the difference in gravitational potential under the General Theory (outside the scope of this paper), and a third correction named as "*for the rotation of the Earth.*" This latter correction is the Sagnac correction; it has nothing whatever to do with relativity. It is the correction necessary because light does not travel around the globe Eastward and Westward in equal times. Invoking SR (still more General Theory) to explain the Sagnac effect is like claiming that the bouncing of a child's ball requires relativity theory to explain it. It is a simple first order effect. Indeed, the President of the CCDS wrote to this author in 1997 agreeing that the Sagnac effect "*is not relativistic.*"

Notes:

- Intl. TeleCom. Union (ITU)
- CCDS (?) / Intl. Clock Synch Agencies



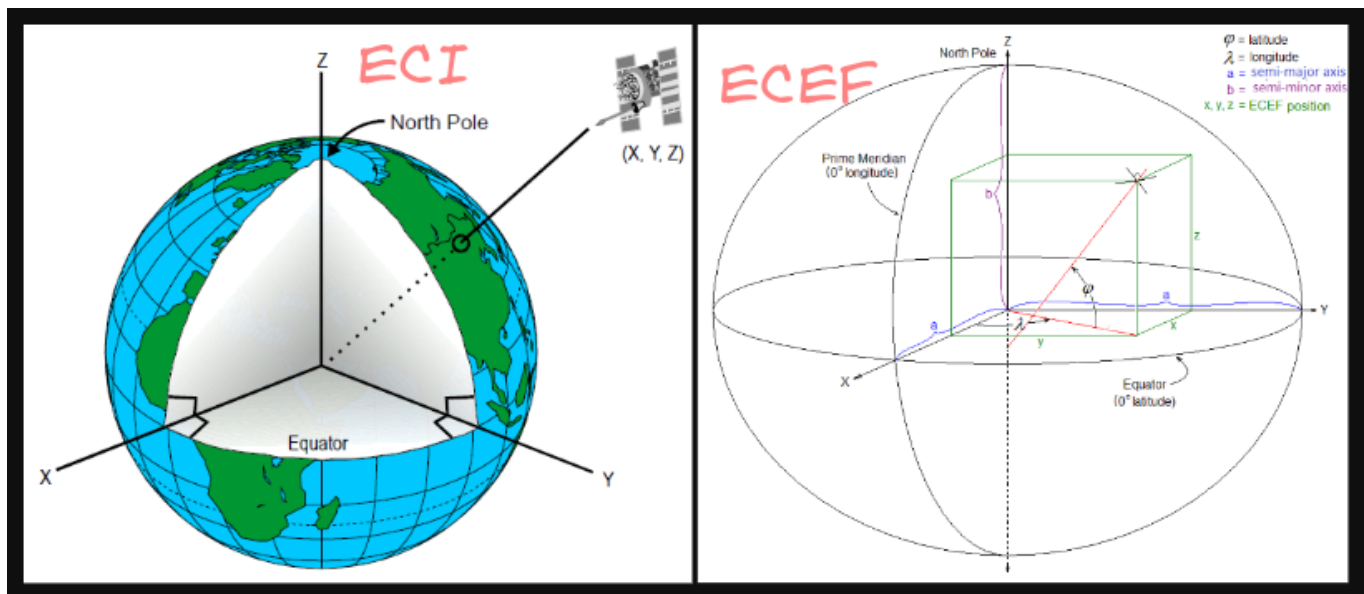
- GR: Gravitational potential: onboard clock
- Sagnac effect (Earth\_v + SV\_v) **Lorentz Boost**

SV-&gt;R

- Measurement taken using RME (Sagnac inherent) to measure  $v/c$  in the receiver
- Sagnac effect (Lorentz Boost)

Now we get into GPS to see if the Relativistic principles hold true

GPS Atomic clock Synch shows the dynamics of relativity theory is false



Notes:

- ECI - Ether Centered Inertial
- Conceptually used as absolute space

- ECI facilitates the one-way measurements

Sungenis, Robert, and Robert Bennett. Galileo Was Wrong: The Church Was Right, 2007.

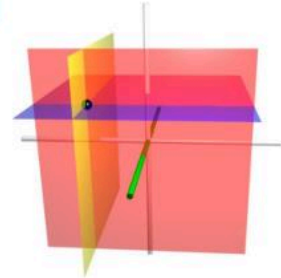
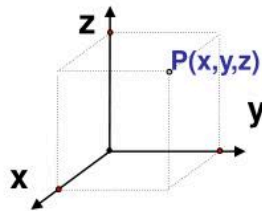
### Orthogonal Coordinate Systems:

#### 1. Cartesian Coordinates

Or

#### Rectangular Coordinates

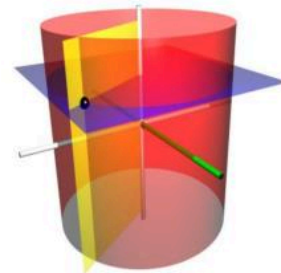
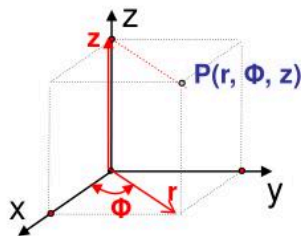
$P(x, y, z)$



#### 2. Cylindrical Coordinates

$P(r, \Phi, z)$

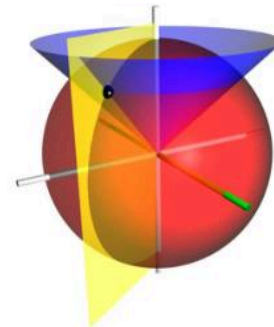
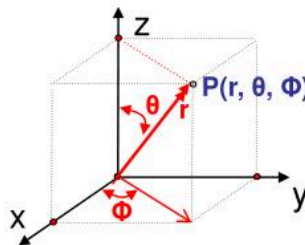
$$\begin{aligned} X &= r \cos \Phi, \\ Y &= r \sin \Phi, \\ Z &= z \end{aligned}$$



#### 3. Spherical Coordinates

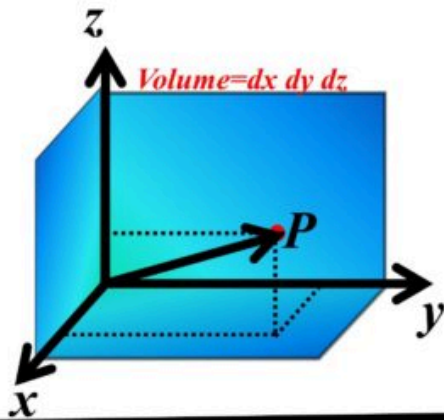
$P(r, \theta, \Phi)$

$$\begin{aligned} X &= r \sin \theta \cos \Phi, \\ Y &= r \sin \theta \sin \Phi, \\ Z &= r \cos \theta \end{aligned}$$

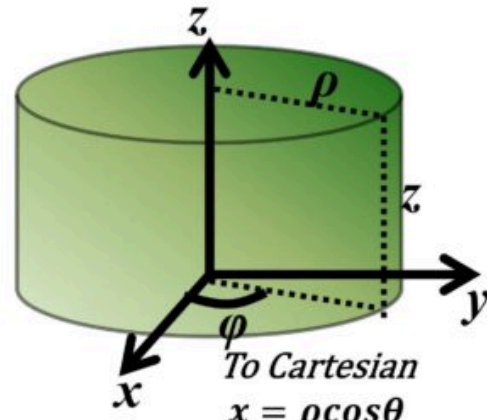


Notes: Coordinate System Simultaneity

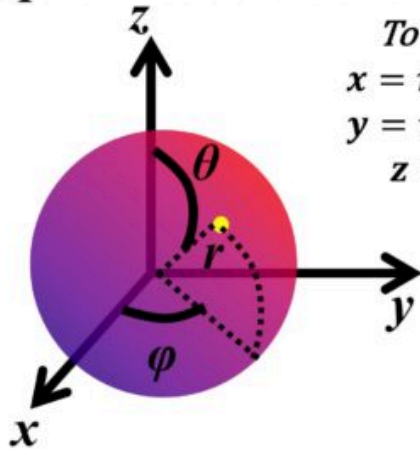
### Cartesian coordinate system



### Cylindrical coordinate system



### Spherical coordinate system



To Cartesian

$$\begin{aligned}x &= r \sin \theta \cos \varphi \\y &= r \sin \theta \sin \varphi \\z &= r \cos \theta\end{aligned}$$

To Spherical

$$\begin{aligned}r &= \sqrt{x^2 + y^2 + z^2} \quad (r \geq 0) \\ \theta &= \cos^{-1} \frac{z}{\sqrt{x^2 + y^2 + z^2}} \quad (0^\circ \leq \theta \leq 180^\circ) \\ \varphi &= \tan^{-1} \frac{y}{x}\end{aligned}$$

To Cartesian

$$\begin{aligned}x &= \rho \cos \theta \\y &= \rho \sin \theta \\z &= z\end{aligned}$$

To Cylindrical

$$\begin{aligned}\rho &= \sqrt{x^2 + y^2} \quad (\rho \geq 0) \\ \varphi &= \tan^{-1} \frac{y}{x} \\ z &= z\end{aligned}$$

Notes:

- Scale invariance

**0.53°**

**DOES WORK FOR A MOON**  
**THE MOON IS 400X CLOSER AND 400X AS SMALL**

**233,400 MILES AWAY**

**&**

**2,159 MILES WIDE**

Notes:

---

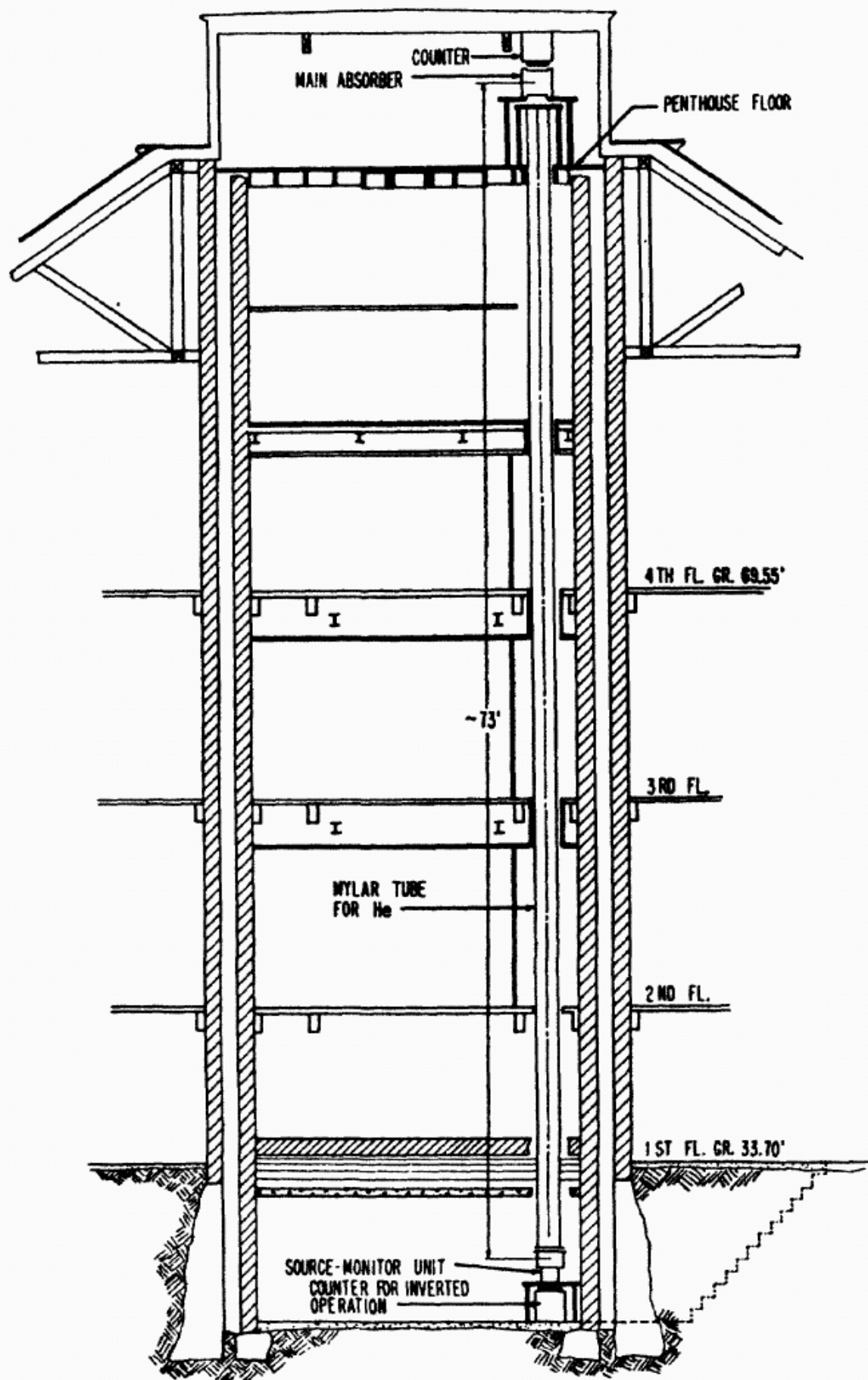


FIG. 2. An architectural sketch of the arrangement of the



system in the enclosed "isolated" tower in the Jefferson Physical Laboratory.

Notes:

- Gravitational potential redshift



Notes:

- Pound Rebka no freq correction needed apparently
- If the concept of a RZA is real
- Latitude dependent gravitational potential corrections would need to be made
- Deflection of the vertical due to the gravitational potential of the geoid is falsified
- If light doesn't require it; how could a plumb bob?
- Linear equipotential vertical "gravitation field" gradient
- How could the geometry of the field be the same horizontally on a curved surface
- Electrostatics?

$$\Delta CD_{\alpha}[v] - \Delta CD_{\beta}[v] = \frac{\ell v}{\varepsilon} \left( \frac{1}{\gamma_{\alpha}} - \frac{1}{\gamma_{\mu}} \right) \quad (9)$$

By definition, we have

$$\frac{1}{\gamma_{\alpha}^2} = 1 - \frac{v^2}{c^2} \quad (10)$$

Since  $v$  is very much smaller than  $c$ , we can use the series expansion of equation (10). We get:

$$\frac{1}{\gamma_{\alpha}} = 1 - \frac{v^2}{2c^2} - \frac{3v^4}{8c^4} \dots \quad (11)$$

Since  $v_{\mu} = v_{\alpha} + \varepsilon$ , we also have:

$$\frac{1}{\gamma_{\mu}} = 1 - \frac{(v + \varepsilon)^2}{2c^2} \dots \quad (12)$$

Equations (11) and (12) in (9) give:

$$\rightarrow (\Delta CD_{\alpha} - \Delta CD_{\beta})\{L\} = +\ell v \frac{v}{c^2} \quad (13) \rightarrow$$

Notes:

Atomic clock synch

- Sadeh et al., 1968 -> Used Sagnac correction for clock synching atomic clocks in trucks driving down the eastcoast
- Saburi et al., 1976 -> Washington -> Tokyo -> Sagnac corrected again
- International Radio Consultative Committee:  
CCIR, 1990 used Sagnac corrections as international clock synch standards

the equations are just Sagnac corrections (Marmet)

Meridian corrections

---

$c \pm v$  between stations.

GPS synchronization has been verified in numerous experiments. It is identical to the calculations presented in this paper and also to the Sagnac's effect (which is included in the GPS). Among the GPS list of corrections, there is a correction involving a parameter taking into account how many Earth meridians are crossed by light or by the moving clock  $\mu$ , between the two locations. Kelly, 1996, explains that the correction used by the GPS is:

$$\text{GPS}(\text{correction}) = 2A_E \frac{\omega}{c^2} \quad (22)$$

where  $\omega$  is the angular velocity of rotation of the Earth,  $A_E$  is the projected area on the Earth equator plane of the path used by light (or by a slowly moving clock) between the two stations. We define  $\ell$  as the distance between the two stations, both moving at velocity  $v$ . The circumference of the Earth is called "circ". Therefore the area  $A_E$  is

$$A_E = \frac{\ell}{\text{circ}} \pi r^2 \quad (23)$$

The angular velocity  $\omega$  is equal to  $v/r$ . The circumference of the Earth is  $2\pi r$ . Equation (23) in equation (22) gives:

$$\text{GPS}(\text{correction}) = \ell \frac{v}{c^2} \quad (24)$$

We see that the GPS correction of clocks (24) is identical to the Sagnac effect, but also perfectly identical to equation (13). When a clock moves

Notes: Meridian corrections = Sagnac corrections based on the SV passing two ground stations

$\ell$  = distance between stations, and the  $v$  of the satellite

Adding Earth's angular velocity to the clock corrections. Why would a satellite in free-fall experience velocity addition or subtraction relative to surface of Earth and not relative to the center of the Earth (fixed, stationary)?

Earth rotation falls under velocity, so it's a SR correction <- MS Narrative

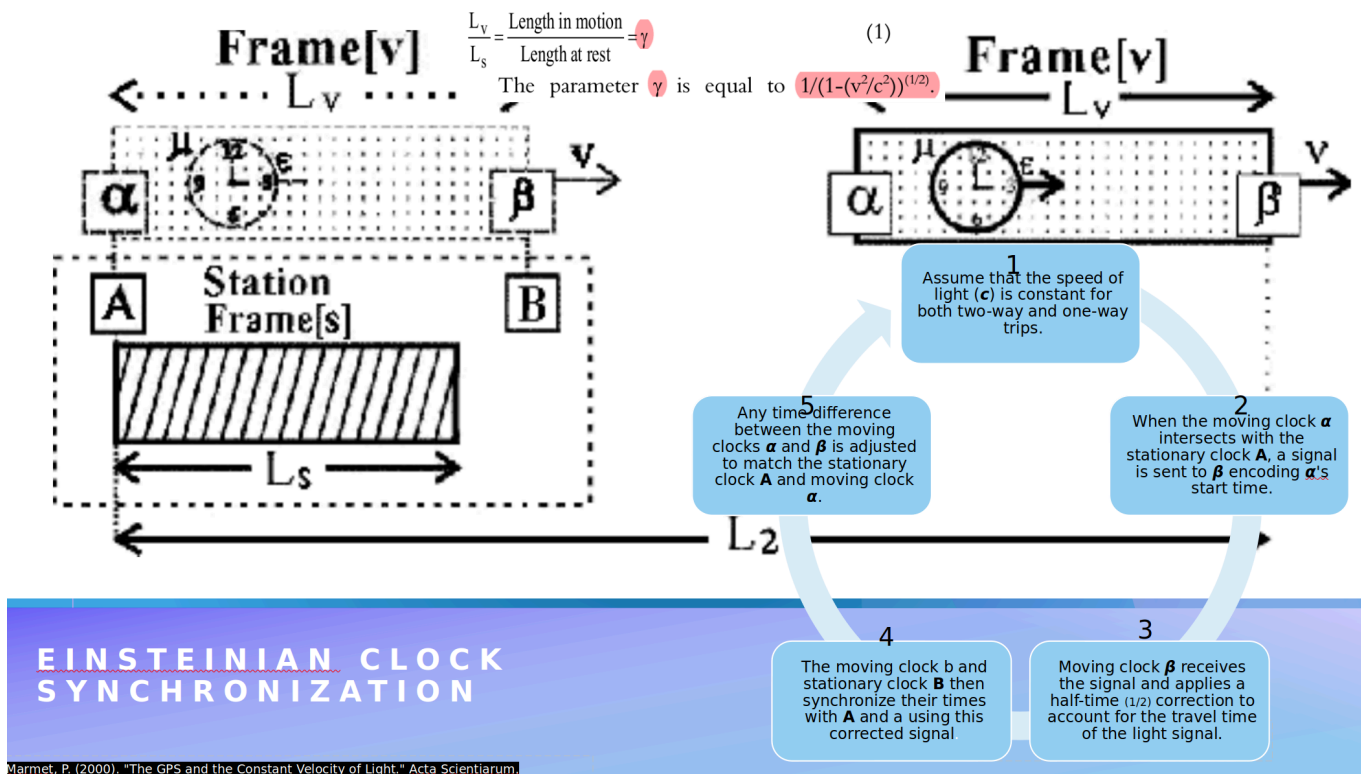
In the original Sagnac test the earth would have turned  $2.8 \times 10^{-13}$  orbital degrees during the test. During a GPS test around the globe at the equator, the earth would have turned by 10,000,000 times the amount it turned during a Sagnac test. Pretending that SR does not apply to rotation, while at the same time applying it daily to experiments like the Global Positioning System, that has a far greater amount of rotation than the Sagnac experiment, is indefensible. We could be forgiven for saying that this is a very biased selection of what is termed an 'Inertial Frame'.

The results are the same for spinning discs of any radius; with a disc of radius approaching infinity, the result approximates to a straight line. The effect thus applies to all objects moving at constant speed. Post (1967) saw that there was a problem with the straight line versus the rotating disc. He said:

*To be consistent with the principle of relativity one has to demand that the Sagnac interferometer and the ring laser cannot lead to a fringe shift or a beat frequency if the equipment is in uniform translational motion. The special theory of relativity does not apply to Sagnac because Lorentz transformations are restricted to pure translation. While this saved the situation from formal contradictions, it did leave a disturbing conceptual discontinuity. Why did galilean kinematics suffice for rotational motion and then fail for pure translation?*

Notes:

- Sagnac in GPS as proposed by Neil Asbhy is a MS cover story
  - Post's comments
-



Notes:

- Einstein's one-way speed and constancy of  $c$  lead to a specific clock sync protocol
- Falsified by Saburi, Jaseja, Tokyo and Washington, truck up and down the East coast
- GS classifies satellites as unaccelerated frames in free-fall
- 1:1 velocity correction for onboard A-clocks
- Not accounted for between SV to GR



# THE SAGNAC EFFECT IN THE GLOBAL POSITIONING SYSTEM

Neil Ashby

*Department of Physics, UCB 390.*

*University of Colorado.*

*Boulder, CO 80309-0390 USA.*

n\_ashby@mobek.colorado.edu

## 2. Local Inertial Frames

Einstein's Principle of Equivalence allows one to discuss frames of reference which are freely falling in the gravitational fields of external bodies. Sufficiently near the origin of such a freely falling frame, the laws of physics are the same as they are in an inertial frame; in particular electromagnetic waves propagate with uniform speed  $c$  in all directions when measured with standard rods and atomic clocks. Such freely falling frames are called *locally inertial frames*. For the GPS, it is very useful to introduce such a frame that is non-rotating, with its origin fixed at earth's center, and which falls freely along with the earth in the gravitational fields of the other solar system bodies. This is called an Earth-Centered Inertial (ECI) frame.

---

Notes:

Neil says  $c = c$  in free fall

- Read pink
-

# RELATIVITY AND THE GLOBAL POSITIONING SYSTEM

**I**t's been almost a century since Einstein introduced the special theory of relativity. All observational tests to date confirm both the special and the general theory. These tests have ranged from sensitive laboratory experiments involving optics, atoms, nuclei, and subnuclear particles to the observation of orbiting clocks, planets,

**We need general relativity to understand extreme astrophysical realms. But the theory also turns out to be essential for the many mundane activities that nowadays rely on the precision of the GPS.**

Neil Ashby

signal reaches the ground, its intensity is only about  $3 \times 10^{-14} \text{ W/m}^2$ . To process such faint signals, GPS receivers must implement very special techniques. Figure 2 shows the new Block IIR satellites on an assembly line.

Data transmitted by the satellites are continuously monitored by receiving stations around the

**Observers in the nonrotating ECI inertial frame would not see a Sagnac effect. Instead, they would see that receivers are moving while a signal is propagating.**

Notes:

Sagnac effect vs Sagnac correction

important applications to geodesy and analogous scientific programs. **RELATIVITY** The precision of GPS measurements is so great that it requires the application of Albert Einstein's special and general theories of relativity for the reduction of its measurements. Professor Carroll Alley of the University of Maryland once articulated the significance of this fact at a scientific conference devoted to time measurement in 1979. He said, "I think it is appropriate to realize that the first practical application of Einstein's ideas in actual engineering situations are with us in the fact that clocks are now so stable that one must take these small effects into account in a variety of systems that are now undergoing development or are actually in use in comparing time worldwide. It is no longer a matter of scientific interest and scientific application, but it has moved into the realm of engineering necessity." According to relativity theory, a moving clock appears to run slow with respect to a similar clock that is at rest. This-effect is called "time dilation." In addition, a

Notes:

- Professor Carroll Alley "GPS wouldn't work without Relativity"
- Professor Alley in 1995 asking for Relativity to put in GPS
- Subria, Jes, etc.

# GPS AND RELATIVITY: AN ENGINEERING OVERVIEW

Henry F. Fliegel and Raymond S. DiEsposti  
GPS Joint Program Office

## Abstract

*We give and explain in detail the formulas for the relativistic corrections to be implemented in high-speed aircraft, or when using other satellites in connection with GPS, or when using GPS from another satellite. We explain how to use these formulas in various scenarios, give numerical examples, and itemize the pitfalls to be avoided by (for example) receiver manufacturers.*

## INTRODUCTION

The Operational Control System (OCS) of the Global Positioning System (GPS) does not include the rigorous transformations between coordinate systems that Einstein's general theory of relativity would seem to require – transformations to and from the individual space vehicles (SVs), the Monitor Stations (MSs), and the users on the surface of the rotating earth, and the geocentric Earth Centered Inertial System (ECI) in which the SV orbits are calculated. There is a very good reason for the omission: the effects of relativity, where they are different from the effects predicted by classical mechanics and electromagnetic theory, are too small to matter – less than one centimeter, for users on or near the earth. However, a new class of users, who employ satellites that obtain time and position in space from GPS, cannot be satisfied with the approximations in the current OCS. Furthermore, because those approximations have not been publicly analyzed and presented, there is much confusion in the GPS literature. Eminent

following. And that if one perhaps does the explicit recognition of the special relativistic effects – I mean, it took a long time to get general relativity down properly, but I think that is more or less correct now. But it's the absence of any explicit acknowledgment of special relativistic effects due to the speed of light being the same whenever measured by an observer, leading to the relativity of simultaneity and the associated Lorentz transformation physics – there's nothing of that at all modeled in the current system, and I think it should be. Thank you.

Notes:

- Never implemented \
- They're all oscillation rate corrections

Additionally one has to ensure that corrections applied to the raw timing data used for orbit determination and the measurement of  $T$  do not presuppose the validity of special relativity. In fact, two corrections are routinely applied to GPS timing data, which are of relativistic origin and therefore do imply  $\delta c = 0$  [7]: the correction for the gravitational redshift and the second-order Doppler shift of the rate of the satellite clock with respect to coordinate time, and the correction for the so-called Sagnac effect, which is due to the rotation of the Earth during signal transmission. Both of these are small corrections of order  $c^{-2}$ ; hence the effect of an error in these corrections due to a nonzero value of  $\delta c$  would be negligible with respect to the first-order effect on  $T$  (for a more detailed theoretical analysis see, e.g., [14]).

Observation of GPS satellites in varying spatial directions thus provides a meaningful test of special relativity via relation (1), with  $D$  obtained using IGS-CODE ephemerides and station coordinates.

Notes:

Wolf and Petit

The dudes who went looking for variance in  $c$ , found it, misnamed it and said no variance.

---

Wolf and Petit (1997) tested the isotropy of the one-way speed of light by analyzing the GPS satellite network timing signal database and found no dependency on source-receiver motion, which they interpreted as evidence that  $c$  was isotropic. However, Wolf and Petit noted that the data set they analyzed had been pre-processed and corrected for the Sagnac effect (in this case, a first-order change in the time of flight of radio signals between satellites and receivers), and justified making this correction by claiming that the Sagnac effect was a relativistic effect that was “second-order in  $c$ ” and therefore that the correction had negligible consequences in their analysis. But the correction that was made was first-order in the velocity component of the line-of-sight between each satellite and the ground receiver in the ECEF frame. Thus, while the affect of the first-order line-of-sight velocity component of the GPS satellites is clearly evident in the raw timing signal data, this first-order component had been removed from the dataset that Wolf and Petit analyzed to show that  $c$  was isotropic.

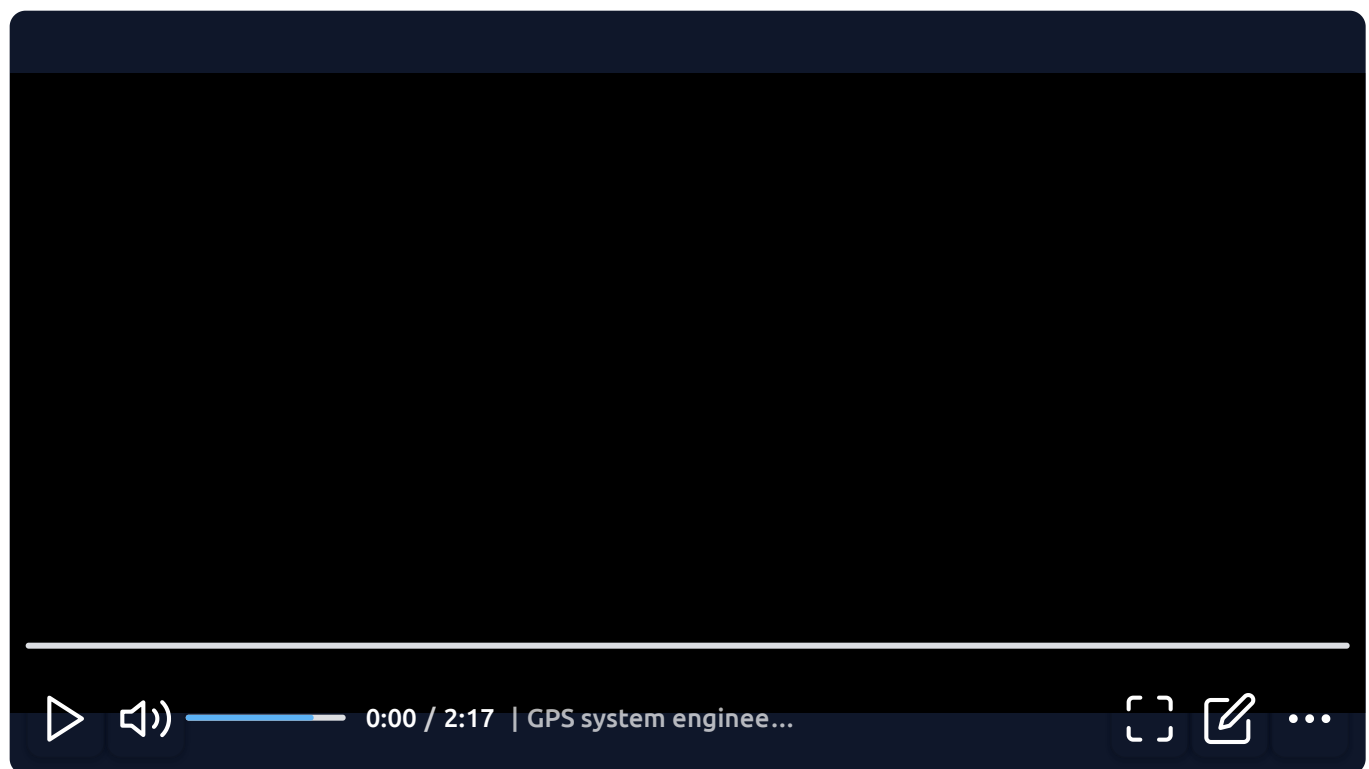
Notes:

Daniel's Analysis

---

Midnight-Noon Redshift

---



Notes:

---

Summary



Notes:

- No cohesive answer to the Sagnac effect, let alone the linearization of it by Wang in 2004.
- Thomas precession conflicts with MMX, which conflicts with MGP.
- Can't use a Lorentz boost to explain the Sagnac effect even though it's the same mechanism (uniform translatory motion and/or acceleration)
- No galactic velocities have ever been meaningfully measured.
- All gravitational influences due to the sun, moon, etc somehow cancel out and are never accounted for in the DYNAMICS of GPS



Notes:

<https://www.youtube.com/@flatearthtests9708/videos> 

Twitter

---

## The Triple Clock Dilemma

In the earlier discussion on SR a number of logical inconsistencies were pointed out involving moving clocks. A similar problem exists with GR. Consider the below diagram:



Three clocks **A**, **B** and **C** are initially moving to the right with an identical velocity. They are perfectly synchronized and according to SR, should remain that way since there is no relative motion.

Suddenly clock **B** begins to accelerate by steadily increasing its velocity. According to GR time dilation should now occur. **B** is accelerating away from **A**, so **B** should slow down relative to **A**. **B** is also accelerating toward **C**, so **B** should speed up relative to **C**. Meanwhile **A** and **C** continue have no relative motion and should remain synchronized. Mathematically that's:

$B < A$  and  $B > C$  and  $A = C$ .

Again we have another impossibility.

Notes: free time dilation paradox for the boyz

---

GINGER -> Can't predict a fringe with GR

Find the first-order dev in the new Sagnac paper