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LINEAR SAGNAC EFFECT, SAGNAC ACCELEROMETER, PROPOSED EINSTEIN'S EQUIVALENCE PRINCIPLE TEST

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1. LINEAR SAGNAC EFFECT

Symmetry Considerations: The idea of the Linear Sagnac Effect originates in Classical Electrodynamics (CED) and theory of Special Relativity (SR) as follows. We have the group of rotations on angle φ (φ being a dimensionless parameter), and we have the group of Lorentz transformations with the parameter V. If we measure time in meters (new $t=ct_{old}$), then the parameter $V=V_{old}/c$ is also dimensionless. **We have a full analogy between φ and V.** Then we have a full analogy between the angular velocity (time derivative of φ) and the acceleration (time derivative of V). We can measure angular velocity by a Sagnac Gyroscope from within the rotating frame. From symmetry considerations, we can conclude that we also could measure acceleration by a "Sagnac Accelerometer" (Based on some kind of linear Sagnac Effect) from within the accelerating frame.

Since the special relativity theory is formulated only for inertial frames (only for these frames the metric is known up front), we have to treat any accelerated frame as an accelerated body described in an inertial frame of reference. What is very important for us is that the speed of light is constant in an inertial frame. At our fist approach we consider that the gravitational field is not present since it is widely believed that the gravitational field can influence the light (bend light rays and cause dependence of the speed of light from coordinates).

Let us make the calculations. Suppose we have a hard stick ABC (AB=BC=d) oriented and accelerated in the x-direction. Let us choose the inertial frame so that at t=0 the linear velocity of the stick is zero. Then the world lines of the points A, B, and C are:

$$A: \quad x = \frac{a}{2}t^2 - d; \quad B: \quad x = \frac{a}{2}t^2; \quad C: \quad x = \frac{a}{2}t^2 + d \qquad (1)$$

At the moment t=0 a light signal is sent from point B in both directions. There are mirrors at points A and C. The light signal meets the mirror C at the moment t_1 which can be found as an intersection of the world line of light x=ct and the world line of C:

$$ct_1 = \frac{a}{2}t_1^2 + d; \quad t_1 = \frac{c}{a}\left(1 - \sqrt{1 - 2ad/c^2}\right) \approx \frac{d}{c}\left(1 + \frac{ad}{2c^2}\right) \qquad (2)$$

Here we used the expansion of the square root up to the second order: $\sqrt{1+\alpha} \approx 1 + \alpha/2 - \alpha^2/8$. The world line of the reflected light signal is: $x = -ct + 2ct_1$, so it arrives back at the point B at the time t_2 (we are using the same technique):

$$-ct_2 + 2ct_1 = \frac{a}{2}t_2^2; \quad t_2 \approx \frac{2d}{c}\left(1 - \frac{ad}{2c^2}\right) \qquad (3)$$

The same calculation for the light signal from B to the mirror A and back to B gives the

time t_2':

$$t_2' \approx \frac{2d}{c}\left(1+\frac{ad}{2c^2}\right); \quad t_2' - t_2 = \frac{2ad^2}{c^3} \qquad (4)$$

The physical meaning of the "Sagnac (or Laser) Accelerometer" should be understandable as follows. Suppose we have a stick with two mirrors on the ends and a light signal bouncing between the mirrors infinitely (supported by a laser). At zero acceleration, the frequency of bounces on the front mirror equals the one on the rear mirror. Suppose now that the stick accelerates. The frequency of bouncing on the front mirror will decrease and the frequency of bouncing on the rear mirror will increase.

The difference of the arrival times (4) can be measured by the one of the interferometric methods used and well developed for the Sagnac gyroscope. We can compare the difference of the arrival times (4) with the Sagnac circular case difference:

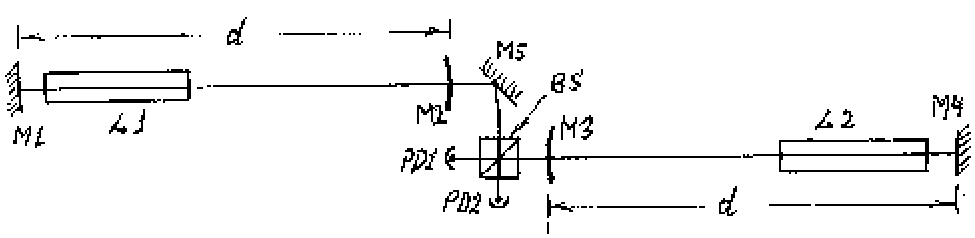
$$\Delta t \approx 8\pi^2 R^2 \nu / c^2 \qquad (5)$$

where ν is the rotation frequency. If we assume that the same interferometric technique is used in the Linear Sagnac Accelerometer and in the Ring Laser Gyroscope then we can equate the difference in arrival times for both devices and arrive at the formula:

$$a_{\min} = \left(\frac{2\pi R}{d}\right)^2 c\nu_{\min} \qquad (6)$$

then we can calculate that if we have a technology that allows us to measure 0.02deg./hour by the ring laser gyroscope, then the same technology in Linear Sagnac Accelerometer will allow us to detect acceleration ~5m/sec^2 ($d=2\pi R$ assumed).

The linear laser is easier to handle compared to a ring laser. The construction of a laser accelerometer is offered as follows:



It consists of two lasers L1 and L2 with semitransparent mirrors M2 and M3, beam splitter BS and two photodiodes PD1 and PD2 based on a solid platform. At rest both lasers adjusted to the same frequency. When accelerated to the right, the frequency at the mirror M2 will decrease while the frequency at the mirror M3 will increase. PD1 and PD2 register the beat frequency. The use of two lasers eliminates the lock-in of the frequencies allowing measurement of very low beat frequencies.

2. ABSOLUTE ACCELEROMETER

The Sagnac Gyroscope measures angular velocity "with respect to light". It allows us to detect **absolute rotation.**

It does not matter if a gravitation field is present or not. The Sagnac Accelerometer measures acceleration also "with respect to light" provided that CED and SR are true and the speed of light is a constant in space. If the laws of nature are symmetric with respect to acceleration and rotation, then the Sagnac Accelerometer should allow us to detect **absolute acceleration** also, it does not matter if a gravitation field is present or not. In free fall, the Sagnac Accelerometer should indicate the actual acceleration (while the usual accelerometer will indicate zero).

But in order for that symmetry to be true, we have to deny the theory of General Relativity and call for another explanation for gravity, for light bending around the Sun, and for other experimental facts, the explanation of which is attributed to the changing of the speed of light. Indeed: if the Sagnac Accelerometer will be able to detect the **acceleration in free fall** then the Einstein's Equivalence Principle(2) between acceleration and gravitation will be violated.

3. DISCUSSION

It is clear that usual accelerometer will indicate zero acceleration in free fall and will indicate 9.8m/sec^2 while sitting unaccelerated on the surface of the Earth. Let us discuss the possible outcomes of the proposed experiment with the Absolute Accelerometer.

1. The Sagnac Accelerometer in free fall will indicate the acceleration 9.8m/sec^2, and will indicate zero while sitting unaccelerated on the surface of the Earth (we neglect a small acceleration due to the rotation of the Earth). In this case we can distinguish between acceleration and gravitation. The "Strong Equivalence Principle" will be proven wrong experimentally and our explanation of gravity and light bending accordingly. The navigation industry will get a device capable of measuring absolute acceleration.
2. The Absolute Accelerometer in free fall will indicate zero acceleration, and will indicate 9.8m/sec^2 while sitting unaccelerated on the surface of the Earth. In this case General Theory of Relativity will get another experimental confirmation that will overweigh all the previous experimental confirmations of General Relativity because it will be a more reliable direct experimental confirmation of the "Principal of Equivalence" and the influence of gravity on the propagation of light.

REFERENCES

1. M. Sagnac, C. R. Acad. Sci. **157**, 708, (1913).

2. A. Einstein, *The Meaning of Relativity,* 5th edition, p.57, Princeton Univ. Press, (1954).