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On the Sagnac Interferometer*:*

A brief List of Calculated Theoretical Predictions

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***Abstract*:**

In this article, the predictions of Maxwell's electromagnetic theory, Ritz's new-source emission theory, Einstein's special theory, and Newton's ballistic theory, with regard to the Sagnac's rotating circular ring, have been computed, in accordance with the much simpler conventional method, in which the two Sagnac light beams are assumed to be traveling along the periphery of the circular ring instead of their actual paths along the sides of the mirror square in the inside of it.

Keywords:

Sagnac interferometer; fringe shift; electromagnetic theory; phase shift; rotating mirrors; new-source emission theory; tangential velocity; ballistic theory; angular velocity; special theory of relativity.

Introduction:

Even though it is not physically true in the strict sense of the term, the assumption that, in the Sagnac classical interferometer, the counterclockwise light beam and the clockwise light beam propagate along the circumference of a circle rather than along the sides of a square, simplifies the calculations of theoretical predictions considerably, and makes the comparison between the calculated values, on the basis of various physical theories, much clearer, without any loss in quantitative accuracy.

In the discussion to follow, the predictions of the electromagnetic theory of Maxwell, the new-source emission theory of Ritz, the special theory of Einstein, and the ballistic theory of Newton, regarding the

the rotating Sagnac circular ring, will be computed by using the above simplifying assumption.

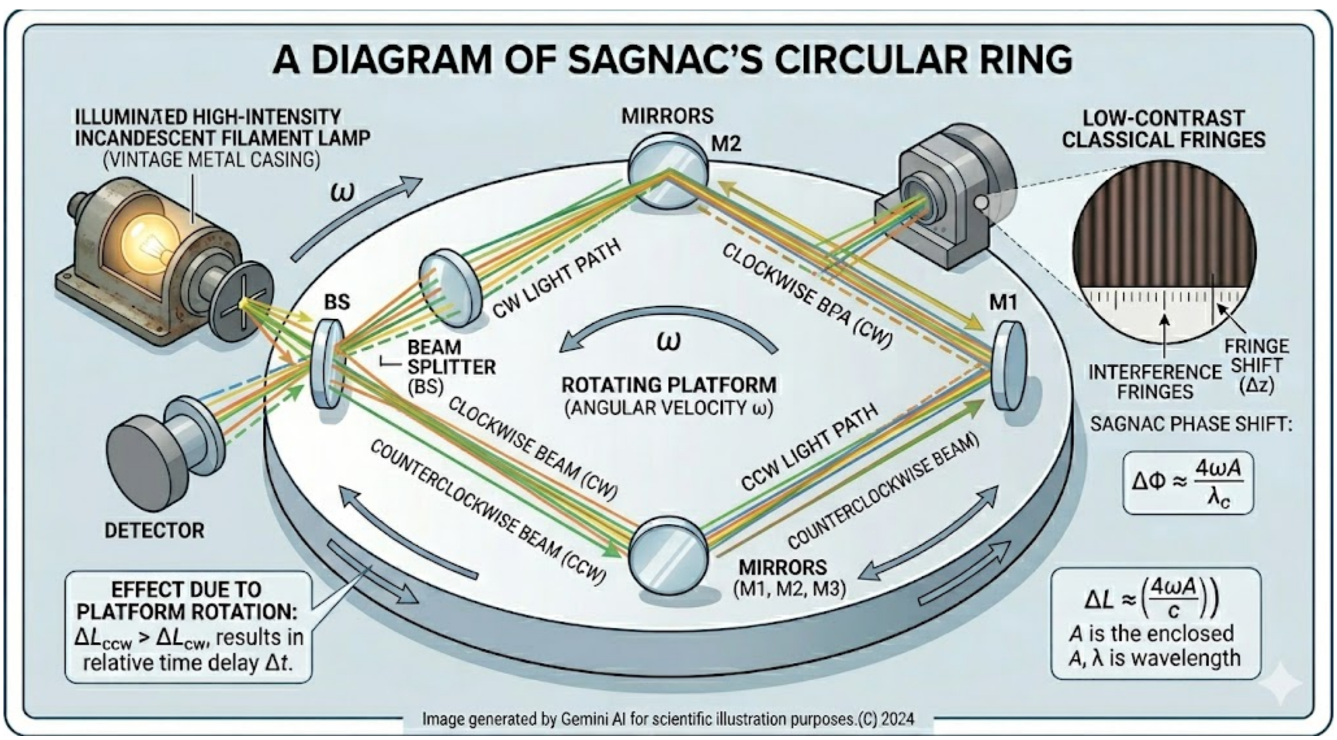
The objective is to determine what each physical theory actually predicts, and whether or not Sagnac-like experiments can, in principle, distinguish, in the physics laboratories, between the quantitative predictions of those physical theories, in a straightforward and precise way.

1. The Classical Sagnac Interferometer:

As shown in the illustration below, by Google Gemini, the initial light beam, emitted by the light source, is split, by the beam splitter, into a counterclockwise light beam and a clockwise light beam.

The counterclockwise light beam is transmitted by the beam splitter in the direction of the rotating Sagnac circular rig to catch up with the fringe-shift detector at a certain speed, the value of which is defined in advance by the physical theory, in question.

The clockwise light beam is reflected by the beam splitter in the opposite direction of the rotating Sagnac circular rig to meet the fringe-shift detector with a specific speed, the value of which is also defined beforehand by the physical theory, under consideration.



2. The Prediction of Maxwell's Electromagnetic Theory:

Let a Sagnac circular ring, whose radius is equal to R, rotate counterclockwise, in a free ethereal space, with the angular velocity ω.

And let t_I denote the travel time of the counterclockwise light beam as well as t_{II} denote the travel time of the clockwise light beam.

The Travel Time of the Counterclockwise Light Beam:

Since the counterclockwise light beam is transmitted by the Beam Splitter in the direction of the rotating Sagnac circular ring, it has to take the following amount of time before meeting the clockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\pi R + R\omega t_I}{c} = \frac{2\pi R}{c - R\omega}$$

where Rω is the tangential velocity; and 2πR is the periphery of the Sagnac circular ring.

The Travel Time of the Clockwise Light Beam:

Because the clockwise light beam is reflected by the Beam Splitter in the opposite direction of the rotating Sagnac circular ring, it must take the following amount of time before meeting the counterclockwise light beam at the fringe-shift detector:

$$t_{II} = \frac{2\pi R - R\omega t_{II}}{c} = \frac{2\pi R}{c + R\omega}$$

where c is the speed of light in Maxwell's aether.

It follows therefore that the time difference Δt between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam is equal to the following amount:

$$\Delta t = t_I - t_{II} = \frac{4\pi R^2\omega}{c^2 - R^2\omega^2} = \frac{4A\omega}{c^2 - R^2\omega^2} \approx \frac{4A\omega}{c^2}$$

where A is the area enclosed by the Sagnac circular ring.

And accordingly, Maxwell's electromagnetic theory has predicted that a certain amount of fringe shift directly proportional to the time difference Δt, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam, will always be registered by the Sagnac fringe-shift detector, as long as the angular velocity ω of the Sagnac circular ring remains greater than zero.

3. The Two Predictions of Ritz New-Source Emission Theory:

Within the framework of the Ritz new-source emission, it's assumed that whenever incident light is reflected or transmitted by a mirror, it loses its initial speed, and the mirror becomes its new source.

In addition, the Ritz new-source source emission theory makes two different predictions, the first one, related to the case in which the Sagnac circular ring rotates in the vacuum, and the second one, related to the case in which it rotates in open air.

Let a Sagnac circular ring, whose radius is equal to R, rotate counterclockwise, in a vacuum, with the angular velocity ω.

And let t_I denote the travel time of the counterclockwise light beam, and t_{II} denote the travel time of the clockwise light beam.

A. In the Vacuum:

The Travel Time of the counterclockwise Light Beam:

Since the counterclockwise light beam is transmitted by the Beam Splitter in the direction of the rotating Sagnac circular ring, it has to take the following amount of time before combing with the clockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\mu R + R\omega t_I}{\sqrt{c^2 + R^2\omega^2 + 2cR\omega\cos(45^o)}} = \frac{2\mu R}{\sqrt{c^2 + R^2\omega^2 + 2cR\omega\cos(45^o)} - R\omega}$$

where 45º stands for the angle between the tangential velocity vector and the direction of the reflected light beam.

The Travel Time of the Clockwise Light Beam:

Because the clockwise light beam is reflected by the Beam Splitter in the opposite direction of the rotating Sagnac circular ring, it must take the following amount of time before meeting the counterclockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\mu R - R\omega t_{II}}{\sqrt{c^2 + R^2\omega^2 - 2cR\omega\cos(45^o)}} = \frac{2\mu R}{\sqrt{c^2 + R^2\omega^2 - 2cR\omega\cos(45^o)} + R\omega}$$

where $R\omega t_{II}$ is the displacement that has been made by the Sagnac fringe-shift detector during the travel time of the clockwise light beam.

It follows therefore that the time difference Δt between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam is equal to the following amount:

$$\Delta t = t_I - t_{II} = \frac{2\mu R}{\sqrt{c^2 + R^2\omega^2 + 2cR\omega\cos(45^o)} - R\omega} - \frac{2\mu R}{\sqrt{c^2 + R^2\omega^2 - 2cR\omega\cos(45^o)} + R\omega} \approx \frac{A\omega \times 1.172}{c^2}$$

And correspondingly, the Ritz new-source emission theory has predicted that a certain amount of fringe shift directly proportional to the time difference Δt, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam, and equal to about the quarter of the amount predicted by Maxwell's electromagnetic theory, will always be registered by the Sagnac fringe-shift detector, as long as the angular velocity ω of the Sagnac circular ring remains greater than zero.

B. In Open Air:

The Travel Time of the counterclockwise Light Beam:

The counterclockwise light beam upon being transmitted by the Beam Splitter in the direction of the rotating Sagnac circular ring, it has to take the following amount of time before meeting the clockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\pi R + R\omega t_I}{\frac{c}{n}} = \frac{2\pi R}{\frac{c}{n} - R\omega}$$

where n denotes the refractive index of air, which is equal to about 1.0003.

The Travel Time of the Clockwise Light Beam:

Since the clockwise light beam is reflected by the Beam Splitter in the opposite direction of the rotating Sagnac circular ring, it must take the following amount of time before meeting the counterclockwise light beam at the fringe-shift detector:

$$t_{II} = \frac{2\pi R - R\omega t_{II}}{\frac{c}{n}} = \frac{2\pi R}{\frac{c}{n} + R\omega}$$

where c/n is the speed of light in open air.

And consequently, the time difference Δt between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam is equal to the following amount:

$$\Delta t = t_I - t_{II} = \frac{2\pi R}{\frac{c}{n} - R\omega} - \frac{2\pi R}{\frac{c}{n} + R\omega} \approx \frac{4A\omega}{c^2}$$

where A is the area enclosed by the Sagnac circular ring.

It follows therefore that the Ritz new-source emission theory has predicted that a certain amount of fringe shift directly proportional to the time difference Δt, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam, which is equal to about the same amount predicted by Maxwell's electromagnetic theory, will always be registered by the Sagnac fringe-shift detector, as long as the angular velocity ω of the Sagnac circular ring remains greater than zero.

4. The Prediction of Einstein's Special Theory of Relativity:

Einstein's special theory of relativity has two different formulations of its second postulate:

- Light travels in the vacuum with the constant speed c regardless of the motion of the emitting body, which is routinely used in the treatment of Sagnac-like experiments.

- Light travels in the vacuum with the same constant speed c relative to all observers regardless of their motions, which is routinely used in the treatment of MMX-like experiments.

The first formulation of the second postulate of Einstein's special relativity is essentially identical to the axiom upon which Maxwell's electromagnetic theory has been built, in accordance with which light travels in the aether with the constant speed c regardless of the motion of the emitting body.

Let a Sagnac circular ring, whose radius is equal to R, rotate counterclockwise, in a vacuum, with the angular velocity ω.

And let t_I denote the travel time of the counterclockwise light beam as well as t_{II} denote the travel time of the clockwise light beam.

The Travel Time of the Counterclockwise Light Beam:

Since the counterclockwise light beam is transmitted by the Beam Splitter in the direction of the rotating Sagnac circular ring, it would take the following amount of time before meeting the clockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\pi R + R\omega t_I}{c} = \frac{2\pi R}{c - R\omega}$$

where Rω is the tangential velocity; and 2πR is the periphery of the Sagnac circular ring.

The Travel Time of the Clockwise Light Beam:

Because the clockwise light beam is reflected by the Beam Splitter in the opposite direction of the rotating Sagnac circular ring, it must take the following amount of time before meeting the counterclockwise light beam at the fringe-shift detector:

$$t_{II} = \frac{2\pi R - R\omega t_{II}}{c} = \frac{2\pi R}{c + R\omega}$$

where c is the speed of light in the vacuum.

And therefore the time difference Δt between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam is equal to the following amount:

$$\Delta t = t_I - t_{II} = \frac{4\pi R^2\omega}{c^2 - R^2\omega^2} = \frac{4A\omega}{c^2 - R^2\omega^2} \approx \frac{4A\omega}{c^2}$$

where A is the area enclosed by the Sagnac circular ring.

As a consequence, Einstein's special theory of relativity has predicted that a certain amount of fringe shift directly proportional to the time difference Δt, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam, will always be registered by the Sagnac fringe-shift detector, as long as the angular velocity ω of the Sagnac circular ring remains greater than zero.

5. The Prediction of Newton's Ballistic Theory of Light:

According to Newton's ballistic theory of light, since the surfaces of the mirrors and the beam splitter of the Sagnac circular ring are parallel to their tangential velocity vectors, neither reflection nor transmission would change the initial combined speeds of the two Sagnac light beams and the speed of the light source.

Let a Sagnac circular ring, whose radius is equal to R, rotate counterclockwise, in a vacuum, with the angular velocity ω.

And let t_I denote the travel time of the counterclockwise light beam as well as t_{II} denote the travel time of the clockwise light beam.

The Travel Time of the Counterclockwise Light Beam:

Because the counterclockwise light beam is transmitted by the Beam Splitter in the direction of the rotating Sagnac circular ring, it would take the following amount of time before meeting the clockwise light beam at the fringe-shift detector:

$$t_I = \frac{2\pi R + R\omega t_I}{\sqrt{c^2 + R^2\omega^2}} = \frac{2\pi R}{\sqrt{c^2 + R^2\omega^2} - R\omega}$$

where $R\omega t_I$ is the displacement that has been made by the Sagnac fringe-shift detector during the travel time of the counterclockwise light beam t_I.

The Travel Time of the Clockwise Light Beam:

Since the clockwise light beam is reflected by the Beam Splitter in the opposite direction of the rotating Sagnac circular ring, it must take the following amount of time before meeting the counterclockwise light beam at the fringe-shift detector:

$$t_{II} = \frac{2\pi R - R\omega t_{II}}{\sqrt{c^2 + R^2\omega^2}} = \frac{2\pi R}{\sqrt{c^2 + R^2\omega^2} + R\omega}$$

where 2πR is the periphery of the Sagnac circular ring.

It follows therefore that the time difference Δt between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam is equal to the following amount:

$$\Delta t = t_I - t_{II} = \frac{2\pi R}{\sqrt{c^2 + R^2\omega^2} - R\omega} - \frac{2\pi R}{\sqrt{c^2 + R^2\omega^2} + R\omega} = \frac{4A\omega}{c^2}$$

where A is the area enclosed by the Sagnac circular ring.

Accordingly, Newton's ballistic theory of light has predicted that a certain amount of fringe shift directly proportional to the time difference Δt, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam, will always be registered by the Sagnac fringe-shift detector, as long as the angular velocity ω of the Sagnac circular ring remains greater than zero.

6. Concluding Remarks:

Is it technically possible for the Sagnac interferometer to distinguish between the theoretical predictions, listed above, in the physics lab?

Although it would be very difficult, in practice, to spot the minute quantitative differences between the aforementioned predictions, it's possible, in principle, to differentiate between the prediction of Maxwell's electromagnetic theory in the aether, the prediction of Ritz's new-source emission theory in open air, and the prediction of Einstein's special theory in the vacuum, on one hand, and the prediction of Newton's ballistic theory in the vacuum, on the other hand, by looking for the amount of fringe shift that correlates with the time difference Δt'' between their exact time differences, between the travel time of the counterclockwise light beam and the travel time of the clockwise light beam:

$$\Delta t'' = \frac{4A\omega}{c^2 - R^2\omega^2} - \frac{4A\omega}{c^2} = \left(\frac{4A\omega}{c^2}\right)\left(\frac{R^2\omega^2}{c^2 - R^2\omega^2}\right)$$

for distinguishing the exact prediction of Newton's ballistic theory from the exact prediction of Maxwell's electromagnetic theory and the exact prediction of Einstein's special theory; as well as:

$$\Delta t'' = 4\pi R\left(\frac{R\omega}{\frac{c^2}{n^2} - R^2\omega^2}\right) - \left(\frac{4A\omega}{c^2}\right)$$

for distinguishing the exact prediction of Newton's ballistic theory, in the vacuum, from the exact prediction of Ritz's new-source emission theory, in open air.

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