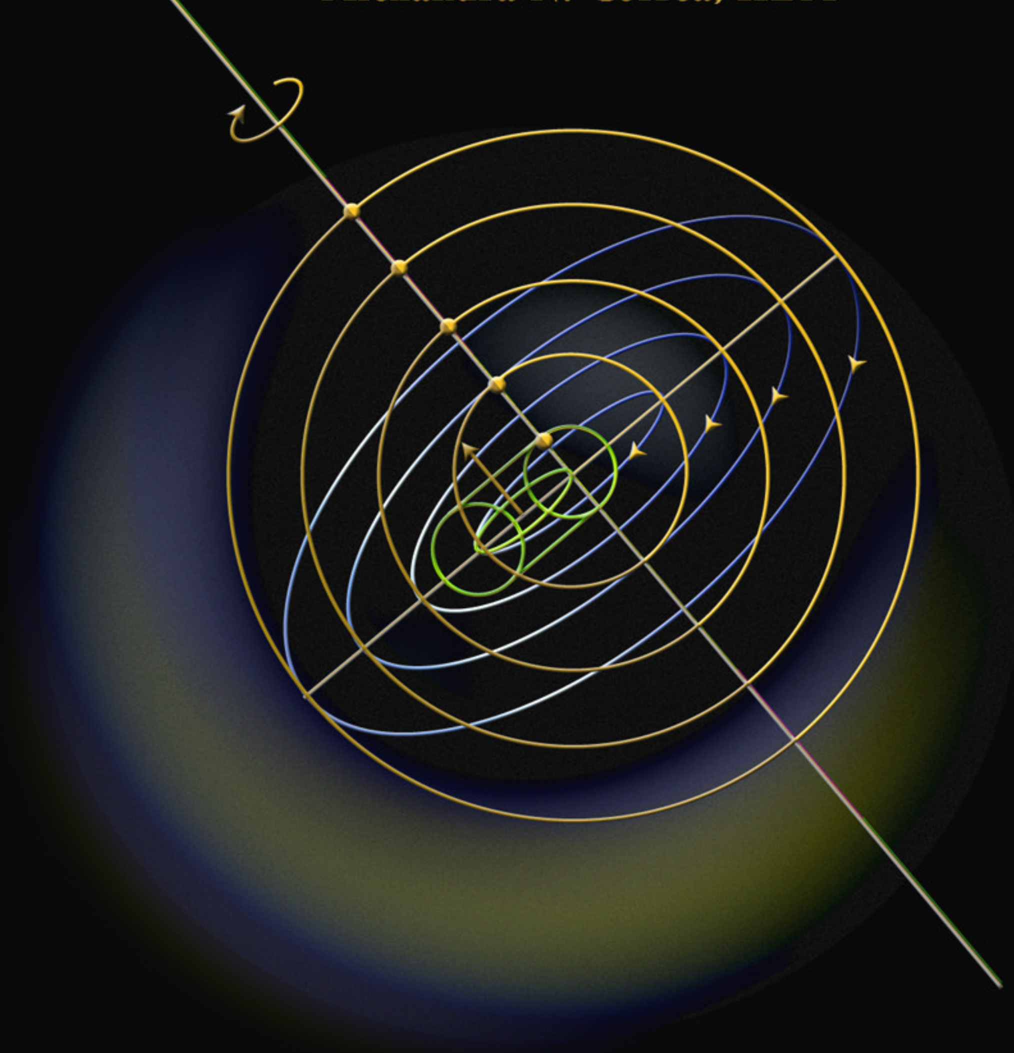
Linear and angular light Doppler shifts and the Sagnac experiment

by

Paulo N. Correa, M.Sc., Ph.D.
Alexandra N. Correa, HBA



ISBN 1-894840-46-1

Published in Canada by
AKRONOS Publishing @ Aetherometry.com

AETHEROMETRIC THEORY OF SYNCHRONICITY (AToS)

VOLUME I

Interferometric Aetherometry (3) -

LINEAR AND ANGULAR LIGHT DOPPLER SHIFTS

AND THE SAGNAC EXPERIMENT:

AETHEROMETRY VS. RELATIVITY (1)

By

Paulo N. Correa, M.Sc., Ph.D. & Alexandra N. Correa, Hon. B.A.
Aurora Biophysics Research Institute

Revised & Edited by Malgosia Askanas, Ph.D.

ABRI Monograph Series AS3-I.3

Aetherom Theory of Synchron **1**, 3: 1-45 (2008)

Linear and angular light Doppler shifts and the Sagnac experiment: Aetherometry vs Relativity (1)

Paulo N. Correa[1], Alexandra N. Correa[1]
Aurora Biophysics Research Institute, Concord, Ontario Canada

ABSTRACT

Without any employ of LF transforms, we present an aetherometric analysis based strictly upon the law of the geometric mean composition of velocities to arrive at the same results that SR obtained for the *linear light Doppler* without invoking a second-order effect, and do likewise for the Sagnac effect to demonstrate the latter is nothing other than an *angular light Doppler* where a 'light loop' is also set in (apparent) motion.

SHORT INTRODUCTION

> "Even if the Aether turned out to be an inertial frame, what right had anyone to assume that this frame was at rest in substantival space, much less that the Aether could be identified with *substantival* space?"
>
> L. Sklar, "Space, Time and Spacetime", 1974, p. 197

What is Aetherometry

"Aetherometry", or "the science of the metrics of the Aether", designates the physico-mathematical study of the manifestations of energy devoid of inertia, ie '*massfree energy*'. Indeed, 'it turned out' that the Aether is *neither at rest*, *nor inertial*, but massfree - and that there is no concrete sensible or physical reality one may call *substantival space*, so claims Aetherometry. 'Aether' in Aetherometry designates *primary forms* of massfree energy, and *not* the luminiferous stationary Aether of the classical theory of Electromagnetism; nor any New Aether, be it the mCBR or the ZPE.

Manifestation of noninertial energy is partially accepted in established physics (tentatively, in the form of particles like the neutrino or the photon), but it is not treated comprehensively (as a distinct domain of energy manifestation) or systematically (by presenting a novel theory of inertia and mass, as does Aetherometry [1-3]). Aetherometry proposes a comprehensive and systematic treatment of massfree energy based upon, *inter alia*:

(1) An exact and quantitative transformation of mass units and dimensionality, into length units and the dimensionality of length [4];

(2) A new mathematical approach - an algebraic theory - to the description and computation of electric fields, their nature and transmission, and the process whereby ordinary charges (massbound electrons, positrons, protons, antiprotons, etc) obtain kinetic energy by coupling to an applied or induced field as a function of the mass of the charge-carriers, without employing relativistic theory or transformations [5-13].

(3) A new physical theory of the photon as a massfree particle [14] and how it is generated by specific metric relations to the electric field and the kinetic energy of emitters [6-10]; it is this theory of the photon that the present paper seeks to present and establish on firm experimental ground with regard to the still open question of the transmission of light and its shifts.

(4) A nascent experimental corpus of evidence for the existence of electric and nonelectric massfree particles, forcing the distinction between primary (massfree) and secondary (massbound) fields or field effects [6-10]. This permitted us to identify the simple physico-mathematical transformation relating the formation of all blackbody spectra to the energy and frequency spectra of primary fields [10, 15]. A test of this hypothesis against the data for the microwave background of cosmic

radiation (mCBR) and the proton background found by Gröte Reber [16-17], showed that both could be produced by the same primary field, with a single, identifiable frequency and energy spectrum [12, 18].

(5) The same theoretical and experimental approach also generated a new geometric model of the inertial, electric and "electromagnetic" structure of the electron that treats the latter as a torus with spin relative to its own inertial frame of reference [15, 19].

All of the new functions and concepts proposed by Aetherometry that are relevant to the present report will be introduced in the course of the presentation.

COMMUNICATION

1. Fundamentals of the aetherometric theory of blackbody photon emission

We have elsewhere presented the aetherometric theory of the photon [10-12, 14], as well as the aetherometric equations for the derivation of the blackbody photon, its energy and frequency, from the kinetic energy which the emitting massbound charge will acquire from *acceleration by an electric field* [11, 15]. Now, precisely one of the critical tenets of aetherometric theory is that massbound charges under acceleration do not emit photons; it is *only when they decelerate* - caused by collisions, electrostatic repulsion or field gradients - that photon emission occurs. If photons are only released from decelerating massbound charges, then emitters are always in motion, in some form of motion or other, or, at the very least, in motion just prior to emission. Photon emission does not mean that the loss of kinetic energy has to be total or complete.

Aetherometry also suggests that light does not consist in the transport of photons (ballistic theory), nor in their transmission by electromagnetic waves. Rays of light, as we shall shortly see, are treated as spatial concatenations of photons that present a given rate of formation in Time. Photons can therefore sequentially concatenate, but that is not what is conventionally meant by transmission of light - not in the sense of traveling electromagnetic waves that transmit light. Since Aetherometry holds that the production of blackbody photons is mediated by moving and decelerating massbound charges, a material medium - and one in motion - always exists for the concatenation of photons into light rays. It is in this domain that one first encounters the aetherometric law of the geometric composition of velocities. It results from the fact that the kinetic energy, and thus the motion, of massbound charges under the effect of an accelerating electric field already *normalizes*, in a real *physical sense*, the electric field velocity (or field wavespeed) to a mean geometric linear particle velocity. The correct definition of the β factor hinges on an adequate understanding of this relation with respect to kinetic energy, and of its variation under conditions when there is growing disproportionation between field energy and resulting kinetic energy [20].

It is strictly in the context of the electric wave of potential W_v that aetherometrically serves as component of acquired kinetic energy, that we write the linear velocity of a massbound charge as a function of its kineto-magnetic and kineto-electric wavespeeds -

$$v = \sqrt{(W_{mag} W_v)} = \beta c \qquad (1)$$

For speeds that are not near-luminal, the voltage of the kineto-electric wave is essentially (ie modally and maximally) the voltage of the applied electric field.

Upon photon emission, another physical normalization occurs - one that transforms the particle's linear velocity function into a lightspeed-invariant wave function that belongs to a different particle (a photon) and is referred to the inertial frame of the emitter. It is in this manner that the Planck constant appears in the description of the process of photon emission from the kinetic energy of a massbound charge. Consider an electron with kinetic energy defined by:

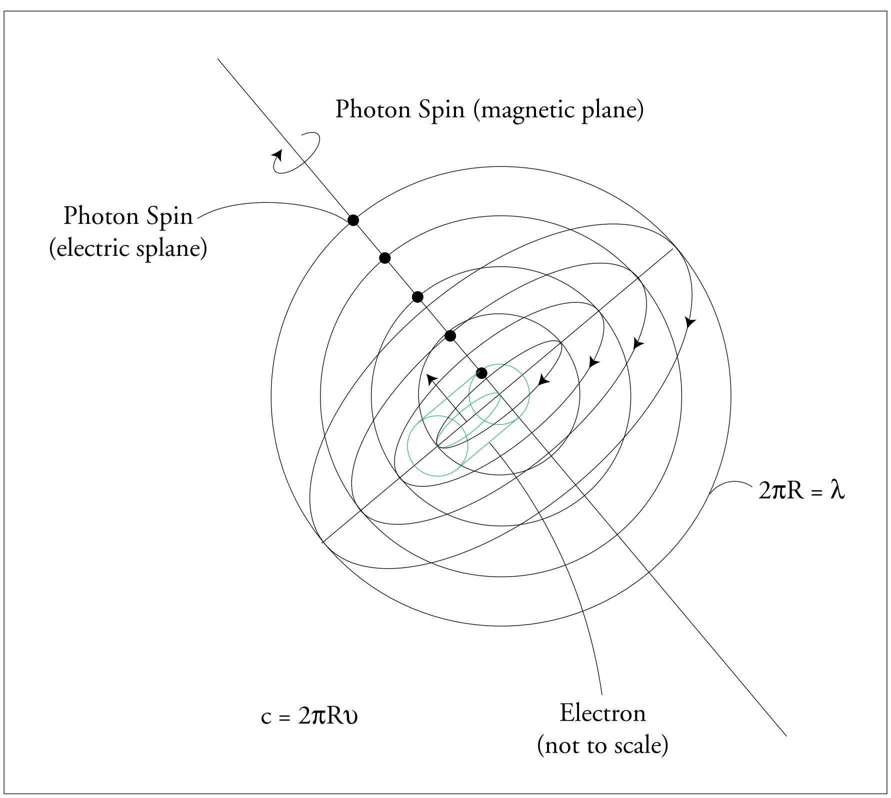
$$E_{ke} = m_e \, (W_k \, W_v) \qquad (2)$$

The photon 'prototype' which this kinetic state can release is limited by the Duane-Hunt law to [11]:

$$\lambda_x \, W_k \, W_v = h \, W_k \, W_v / e = h\upsilon = \lambda_0 \, c^2 \qquad (3)$$

As we said above, there is no transmission of light *per se*, just a virtual concatenation of photons; but there is a transmission or propagation of a light-inductive or light-permissive stimulus, and this is precisely the propagation of the electric field that accelerates charges to begin with. Under conditions where there is no significant disproportionation between the *energy and velocity of the primary field*,

Fig. 1A
Photon emission in the electron inertial frame:
globular structure of photon & growth in the 1/v interval



on one hand *and*, on the other hand, the *kinetic energy and electric wavespeed of the accelerated mass-bound charges*, we can simplify the complete aetherometric argument so that the electric field is simply (for an electron):

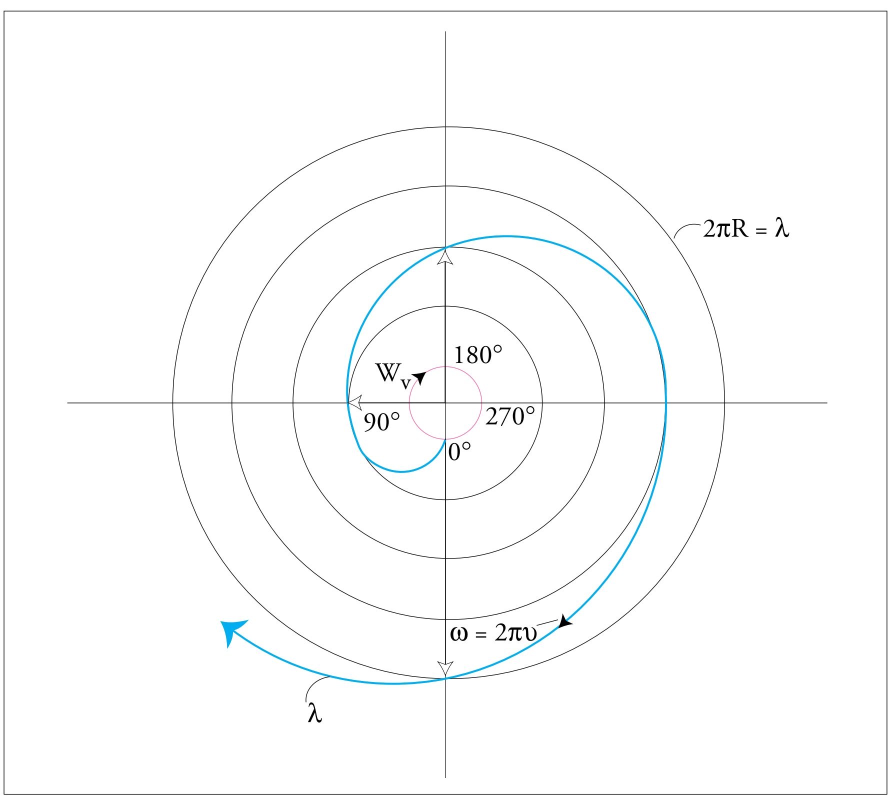
$$\varepsilon = W_v/\lambda_e =\!\int\!= V/m_e \tag{4}$$

where the sign $=\!\int\!=$ denotes an exact aetherometric conversion or set of quantitative transformations relating volts to wavespeed and mass to wavelength equivalent. The kinetic electric wavespeed of the electron is essentially the field velocity given by:

$$W_v = \lambda_e\, \varepsilon \tag{5}$$

If photons have invariant wavespeeds c referenced to the inertial frame of the emitter, then the predicted aetherometric volumetric structure of the photon is globular (see **Figures 1A & 1B**), and not fascicular (nor toroidal, like the structure of the energy flux constitutive of an electron). A photon

Fig. 1B
A single photon wavefunction: spin on one plane



would form a local, spinning globule of energy, and this would be the deep reason why its emission 'unfolded' a spherical envelope. The motion vector(s) of the emitter would alone give direction to photon formation or 'eruption', distorting the globule in the main direction of motion. If the emitting electron is moving, the photon will also move with the charge, for a short time interval given by $1/\upsilon$. For emitter velocities that become near luminal - in other words, when considering the resulting and corresponding "high frequency optothermal" (HFOT) photon blackbodies - this distortion becomes significant. The example shown in **Fig. 2** for a single wave function of the photon, is for an HFOT emission with a frequency of 10^{15} Hz discharged from an electron with a linear velocity of slightly over 1/3rd the speed of light.

Since the emitter must always be in motion, a light ray can be thought of in two different ways. On one hand, it is a diachronic concatenation of photons emitted from a single decelerating charge and which, from any frame substantially at rest relative to the speed of the emitting charge, appear smeared like strung pears. This is shown, schematically for any arbitrary segment of a ray, in **Fig. 3**, and describes what we would call a filamentary ray. But a light ray is, on the other hand, a composite of many filamentary rays, where many emitters (for a given field gradient) share a collective modal behaviour and decelerate, at different and sequential positions in abstract space (according to the 'distribution' of the fields in space), to emit similar photons at coincident or nearly-coincident times. In monophasic light, all filamentary rays are identical in frequency (and thus wavelength). The same happens in (narrow) line spectra. In dispersive light, however, filamentary rays vary in frequency. Modal frequency shifts then occur when the main grouping of monophasic filamentary rays shifts its frequency mode.

Once expressed or produced, photons dissipate locally, conveying the shed kinetic energy to the 'vacuum state'. However, if another charge lies within the radius of the photon globule, ie at a distance $d<(\lambda/2\pi)$, and its kinetic characteristics are resonant with those of the emitted photon, the proximal charge can absorb the entirety of the local photon energy.

2. The Doppler shift in sound

2.1. Asymmetry of reception with respect to a material medium for sound

In the transmission of sound there is an important asymmetry relating the state of motion of either the sound source or the receiver to *a medium considered to be at rest*. The asymmetry is traditionally explained by the existence of a medium for the longitudinal and spherical propagation of sound waves; the medium regulates or normalizes the propagation velocity of the mechanical pressure waves (of alternating compaction and expansion of a mass of air molecules) to a near-invariant value that depends on the pressure, temperature and chemical composition of the medium (331.3 m/s for air at 0°C and 1 atm). The acoustic medium is necessarily a material one, since sound does not exist *in vacuo*.

Fig. 2

Planar distortion of a single blackbody photon wavefunction in the direction of electron emitter motion with velocity **v**.

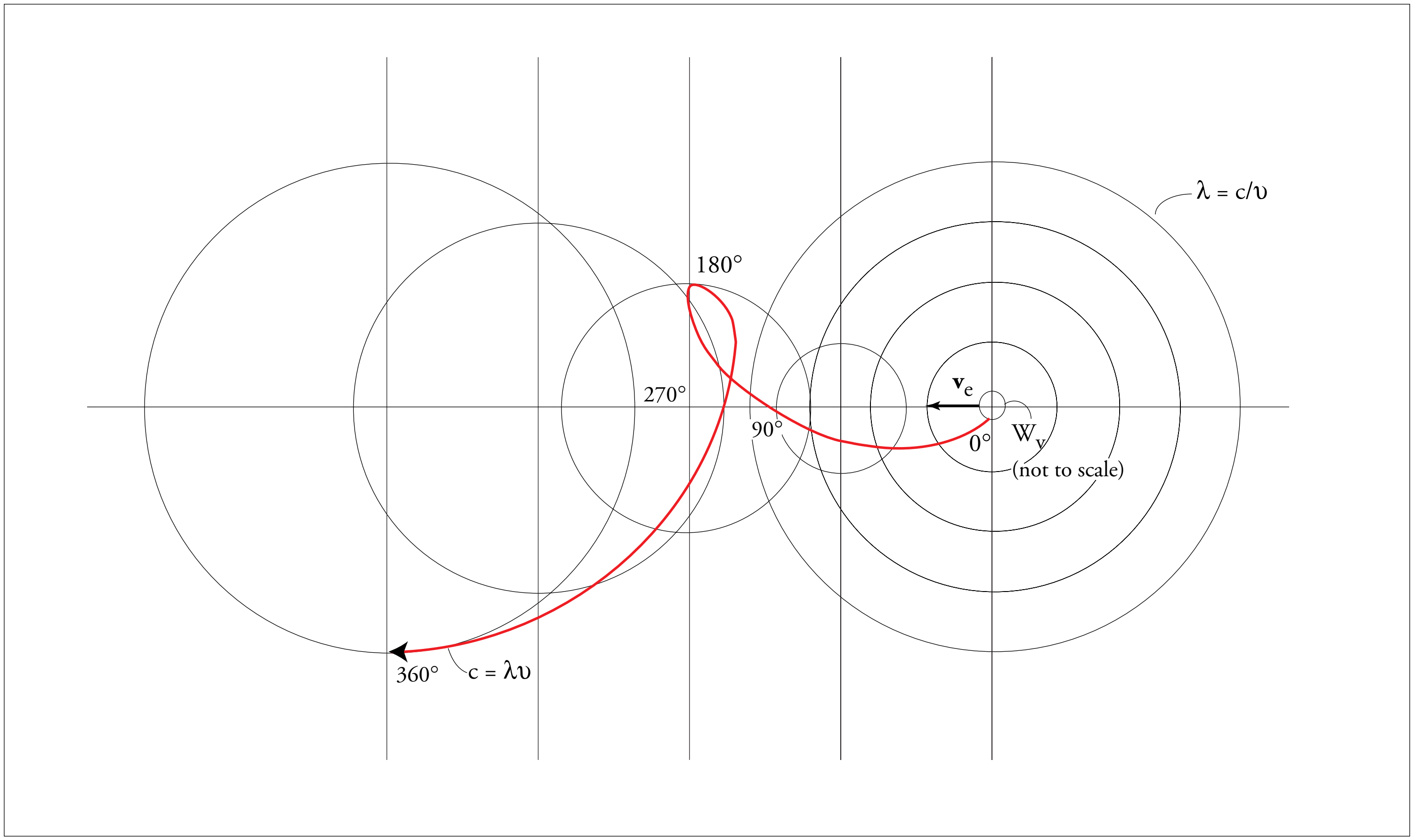
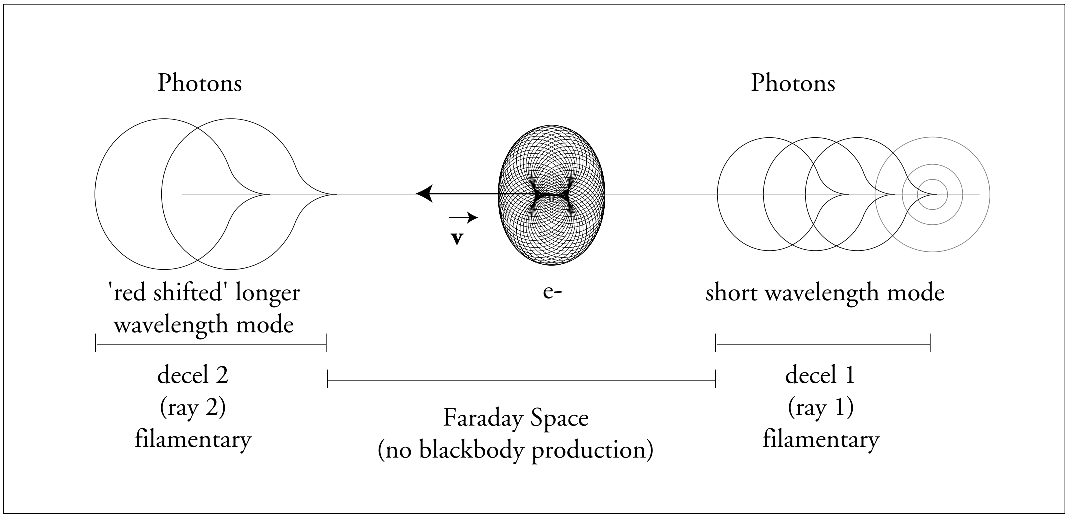


Fig. 3
Decelerating electron with blackbody emission modes
(photons schematically represented as being distorted like drops)

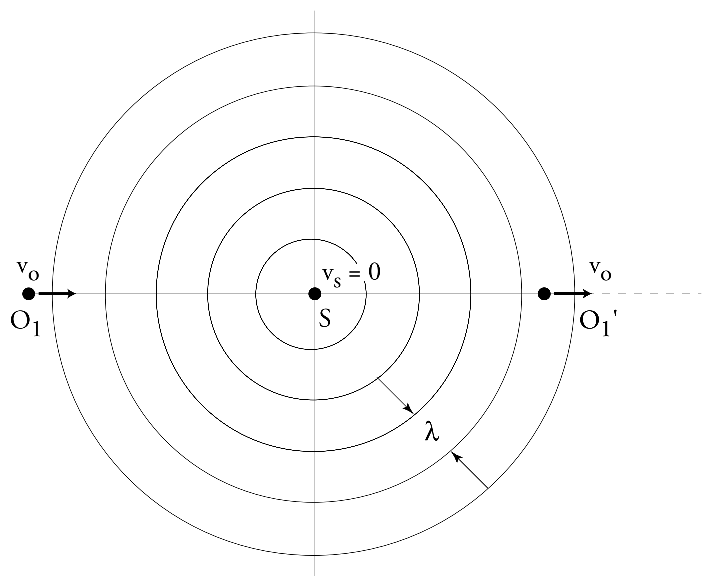


2.2. Receiver approaching to, or receding from, the source

When the sound source is fixed to the medium (which means: when its motion is in all respects that of the medium, and thus the source and the medium share the same inertial frame of reference), *an observer or receiver moving along the 'straight line' joining it to the source* (to avoid introducing trigonometric factors in this presentation) *will either intersect, in a given time period, more of the spherical longitudinal waves coming from the source* - if it is approaching the source and thus contracting the path traveled by the sound waves before detection - *or will instead intersect fewer of the same waves* - if it is receding from the source and thus extending the path traveled by the sound waves before detection - *than it would if it were also stationary in the medium or fixed to it*. Accordingly, the observer or receiver will hear or register a sound pitch higher than the pitch at the source if approaching the latter, and lower if receding from it. The distance between wave cycles at the source being the wavelength of the sound waves, the approaching listener intersects more of them per unit time when moving towards the source than if stationary, and less of them per unit time when receding from the source (see **Fig. 4**).

Let v denote any medium-invariant sound speed, and let f denote the sound frequency in cycles per sec. The Doppler effect for a listener moving with velocity v_o with respect to the sound source will affect the heard or registered frequency f' to differ from the original frequency of the sound emitted at the source, as per the relation:

Fig. 4
Sound Doppler effect:
Source fixed (stationary) in sound medium;
observer moving relative to it:
O_1 moving towards source, O_1' moving away from source



$$f' = f\,[1 \pm (v_o/v)] \tag{6}$$

If the listener is receding from the source, the pitch will decrease:

$$f' = f\,[1-(v_o/v)] \tag{6a}$$

If the listener is approaching the source, the pitch will increase:

$$f' = f\,[1+(v_o/v)] \tag{6b}$$

2.3. Source approaching to, or receding from, the observer

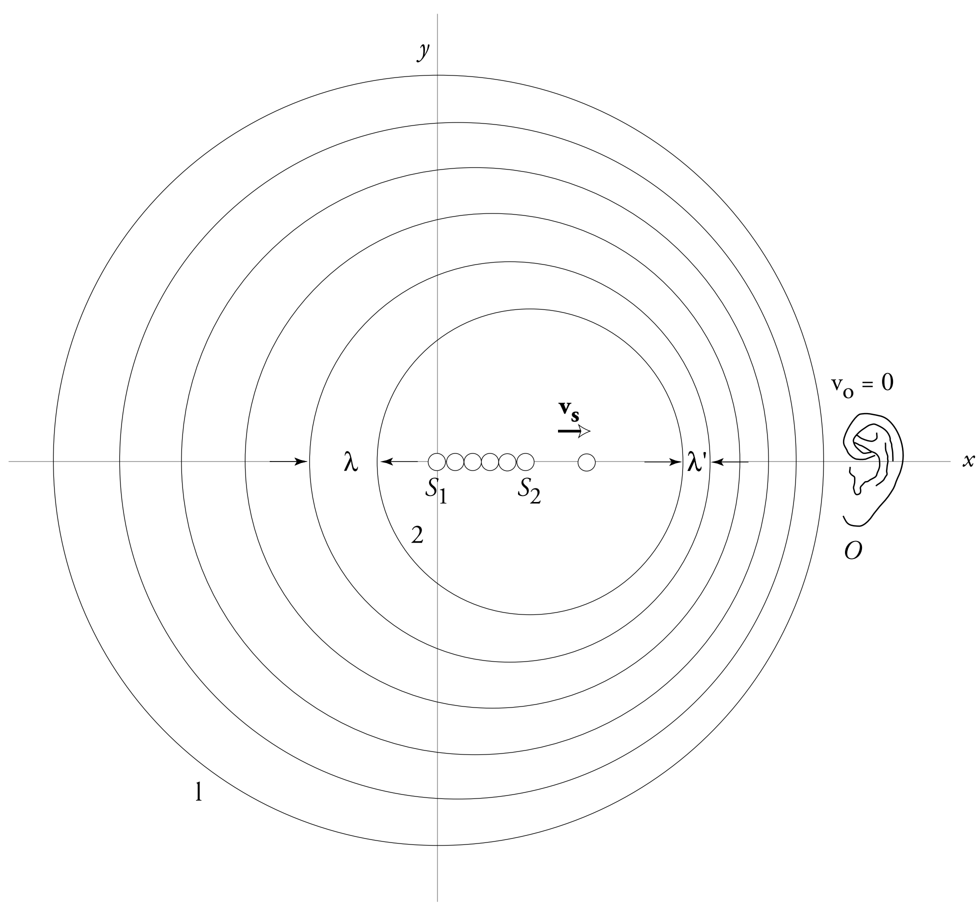
The asymmetry consists in the fact that, if the observer is, instead, stationary in the local sound medium and it is *the source that moves relative to the observer and the medium*, the listener will still hear a higher or a lower pitch according to whether the source approaches or recedes from the receiver. But assuming that the velocity v_s of motion of the source is the same as the velocity we before attributed to the moving listener, *the measured frequency shifts will be smaller for receding motion and* *greater for approaching motion than those registered when it is the observer that moves and the source that is fixed with respect to the medium*. This is apparent from the function:

$$f' = f/[1 \pm (v_s/v)] \quad (7)$$

If the source is approaching, the pitch will increase:

$$f' = f/[1-(v_s/v)] \quad (7a)$$

Fig. 5
The Doppler effect due to motion of the source. The observer is at rest.
Wavefront 1 was emitted by the source when it was at S_1,
wave front 2 was emitted when it was at S_2, etc.
At the instant the 'snapshot' was taken, the source was at S.
(after Halliday, 1978, Figure 20-11, p. 447)



and if it is receding, the pitch will decrease:

$$f' = f / [1+(v_s/v)] \quad (7b)$$

Indeed, when a source approaches or recedes, the situation is no longer one where the listener is moving at a given velocity through concentric rings marking the sound cycles and spaced equally along the path of motion. Instead, the spherical envelopes of the sound waves perceived by the observer are now excentric and *regularly displaced* along the path of the source's motion, either towards the receiver if the source is approaching, or away from it if the source is receding (see **Fig. 5**). *The observed frequency shifts are therefore asymmetrically different, according to whether the observer or the source move with respect to the sound medium.*

2.4. The classical Doppler for simultaneous motion of source and receiver

When *both* source and receiver *move* with respect to one another and also with respect to the sound medium, the sound Doppler effect integrates both asymmetric contributions, as a function of the invariant medium velocity: if the source and listener are converging -

$$f' = f [(v+v_o)/(v-v_s)] \quad (8a)$$

and if they are separating -

$$f' = f [(v-v_o)/(v+v_s)] \quad (8b)$$

such that we may write the overall integrating function as:

$$f' = f [(v \pm v_o)/(v \mp v_s)] = f [1 \pm (v_o/v)]/[1 \mp (v_s/v)] \quad (8)$$

When either v_o or v_s go to zero, the previous asymmetric functions result. The asymmetry, then, consists in the fact that for the same relative motion of a source and an observer, the results are quantitatively different depending on whether the source or the observer is moving; this is so because the source and observer velocities are *referenced to the medium* in which the sound waves propagate, and the medium determines a relatively invariant sound wavespeed.

When either the speed of the source or that of the listener exceeds the speed of sound in the medium, the Doppler shift becomes ineffectual: if the observer moves away from the source faster than v, then the sound wave will never catch up with it and will not be heard; and if it is the source that moves through the medium faster than v, then the source will move faster than the sound waves in some direction, giving rise to a conical envelope of wavefronts or what is known as a *supersonic shockwave*.

Some pro-relativist presentations, like that of P. French [21], introduce the SR treatment of light as a unification of the two acoustical Doppler effects, as if the classical Doppler formulation did not include equation #8 above: "The relativistic result [from SR] is a kind of unification of the moving-source and moving-observer results and can be set equal to either if terms higher than the first order are ignored."

In fact, if terms of a higher order are neglected, SR contributed *nothing* new to that unification which was already present in the classical treatment of the acoustical Doppler effect. Where SR can claim to have made a contribution is with the introduction of the second-order term into the Doppler effect of light 'transmission' relative to moving inertial frames, and thus introduction of a differentiation towards the classical Doppler treatment of light, not sound - as we will see in the next section.

3. The Doppler effect in light 'transmission': classical and relativistic approaches

3.1. The classical approach to light 'transmission'

The acoustic Doppler equations that apply *when the receiver is in motion* were used by classical electromagnetic theory to approximate the Doppler shift in light. By reference to the line radiation of specific elements, the broadening of the emission lines in hot gases was understood early on as the result of a Doppler shift caused by increased kinetic energy and the wider and faster spread (diffusion) of the gas molecules in all directions.

The assumption was, at first, that there was a medium for the transmission of light and that the speed c/n filled the same role as the medium-dependent invariant sound velocity *v* played in the propagation of sound, the effect being also first-order with respect to velocity: thus, for a vacuum, where the index of refraction is 1 (and c/n = c), and for an observer moving away from a source of light, we could write -

$$\upsilon' = \upsilon\ [1 \pm (v_o/c)] \qquad (9)$$

Now, what happens if the source is moving instead? Well, that's the problem: one can understand a source at rest in an inertial system of reference, and the observer or receiver moving away or towards it - just as one can understand the reverse, an observer at rest in a system of inertial coordinates and the source moving away or towards it, but since one cannot privilege either system of coordinates as the system of coordinates that belongs to the medium of the 'transmission' of light, it is neither the velocity of the source v_s nor of the observer v_o relative to the medium that matters, *but solely the relative velocity v of the motion of conjunction or disjunction between source and observer*.

Thus, for either conjunction or separation (see first line of **Table 1**), the classical approximation resulted in -

$$\upsilon' = \upsilon\ [1 \pm (v/c)] \quad (10)$$

If we compare this equation to the classical equation for sound propagation (see equation #8 above), one can see how simply changing v_o to v does not replicate the integral classical treatment of the acoustical Doppler so as to apply it to the 'transmission' of light.

Table 1
Linear Doppler Effect for Light
(for emitter and receiver moving along an imaginary straight line between them)

Test Parameters: $v = 10^7$ m sec^{-1} (relative velocity of emitter and receiver)
$\upsilon = 10^{15}$ sec^{-1} (emission frequency)
$\lambda = c/\upsilon$ (emission wavelength)

Model	Approaching $\upsilon_H = \upsilon'$	Test values * 10^{15} sec-1	Receding $\upsilon_L = \upsilon'$	Test values * 10^{14} sec^{-1}
Classical (like observer sound-Doppler)	$\upsilon' = \upsilon[1 + (v/c)] = (c + v)/\lambda$	1.0335641	$\upsilon' = \upsilon[1 - (v/c)] = (c - v)/\lambda$	9.666435905
SR	$\upsilon' = \upsilon[1 + (v/c)]/[1 - (v/c)^2]^{0.5}$	1.033931772	$\upsilon' = \upsilon[1 - (v/c)]/[1 - (v/c)^2]^{0.5}$	9.671818077
GGT	$\upsilon' = \upsilon[1 + (v/c)] * [1 - (v/c)^2]^{0.5}$	1.032781367	$\upsilon' = \upsilon[1 - (v/c)] * [1 - (v/c)^2]^{0.5}$	9.661056728
AToS	$\upsilon' = \upsilon\{[1 + (v/c)]/[1 - (v/c)]\}^{0.5}$	1.033931772	$\upsilon' = \upsilon\{[1 - (v/c)]/(1+ (v/c)]\}^{0.5}$	9.671818077
Arithmetic Mean of both sound-Dopplers applied to Light	$\{\{\upsilon[1 + (v/c)]\} + \{\upsilon /[1 - (v/c)]\}\}/2$	1.033931932	$\{\{\upsilon[1 - (v/c)]\} + \{\upsilon /[1 + (v/c)]\}\}/2$	9.670781148
What observer would see if source sound-Doppler applied to light	$\upsilon/[1 - (v/c)]$	1.034507454	$\upsilon/[1 + (v/c)]$	9.677203246

3.2. SR's treatment of the Doppler shift in light

If, in the domain of light, the source receding from the observer yielded identical results as the observer receding from the source, and likewise for their conjunction, then it would seem that all observed frequencies were *just relative to the observer's state of motion with respect to the source, but irrespective of the state of motion of the source*. From experimental results, it was obvious that applying the acoustical Doppler formula for the moving observer gave better results than applying the complete acoustical Doppler formula for both observer and source moving. For example, for a relative speed of 10^7 m sec^{-1} between approaching observer and source, and with an emitter frequency of 10^{15} Hz, the *complete classical Doppler applied to light* gave:

$$\upsilon' = \upsilon\ [1+(v/c)]/[1-(v/c)] = 1.069014909*10^{15}\ \text{Hz} \tag{11}$$

whereas the *partial classical Doppler* based on motion of the *observer* gave:

$$\upsilon' = \upsilon\ [1+(v/c)] = 1.03335641*10^{15}\ \text{Hz} \tag{12}$$

much closer to the observed result of $1.03393*10^{15}$ Hz (compare the first and second lines of Table 1).

Something was missing in the classical "moving-observer"-based Doppler treatment of light 'propagation'. *No medium for light 'propagation' could be found with reference to which either source or observer could be said to be at rest, and there was therefore no a priori way to know who or what was moving, whether the source, the observer or both*. If only the relative displacement between source and receiver mattered, one could safely abstract the existence of a medium, even if one existed.

Yet, if no medium existed, something in the vacuum at least appeared to normalize the so-called 'lightspeed' to an invariant value - and this normalization was not simply the result of applying the complete acoustical Doppler to light. But the normalization could be approached by invocation of second-order corrections called forth, in essence, by the Lorentz-Fitzgerald transformations.

The question of whether or not to keep to the existence of a medium for the 'transmission of light', then devolved to the question of what to do with these corrections to the classical Doppler effect - either incorporate them into the abstract structure of a medium with reference to which absolute speeds could be determined, or conceive them as part of the physical structure of light and space, where only 'lightspeed' has an absolute value. Often this boiled down to the question of whether to multiply by the second-order correction term (Ives, Gagnon, etc), or divide by it (Einstein's SR) - which in practice results in quantities that vary so infinitesimally that they cannot actually be told apart.

The formulation that triumphed was not Larmor's, Ives', or any other than Einstein's SR. It suggested that a separation at relative velocity v was to be second-order corrected by division by the term $[1-(v/c)^2]^{0.5}$, such that the resulting *redshift* would be given by [22] -

$$\upsilon' = \upsilon\ [1-(v/c)]/[1-(v/c)^2]^{0.5} \qquad (13a)$$

For a conjunction of source and observer, the *blueshift* would be (with -v as v):

$$\upsilon' = \upsilon\ [1-(-v/c)]/[1-(-v/c)^2]^{0.5} = \upsilon\ [1+(v/c)]/[1-(v/c)^2]^{0.5} \qquad (13b)$$

so that, in general:

$$\upsilon' = \upsilon\ [1\pm(v/c)]/[1-(v/c)^2]^{0.5} \qquad (13)$$

It is important to note that this amounted to a predicted normalization of the Doppler shift whose exactitude was difficult to confirm . Using the parameters of the above example, it predicted a result of

$$\upsilon' = \upsilon\ [1+(v/c)]/[1-(v/c)^2]^{0.5} = 1.033931772*10^{15}\ \text{Hz} \qquad (13c)$$

either coincident with the result or, at the very least, obviously closer to the measured results than the classical formula - to which it reduces when v is much less than c, thus making the second-order term negligible (see below). With these qualifications, then, the SR formula could be confirmed.

Yet, one would not be able to distinguish the SR result from, for example, the ordinary algebraic mean of the results yielded by the two distinct acoustical Doppler formulas (for the moving observer and the moving source) applied to light. Indeed, for the values of the example for approaching observer and source given above, the ordinary mean (see fifth line in **Table 1**) would yield:

$$\{\{\upsilon\ [1 + (v/c)]\} + \{\upsilon/[1 - (v/c)]\}\}/2 = 1.033931932*10^{15}\ \text{Hz} \qquad (14)$$

Thus, please remark that

$$\upsilon' = \upsilon\ [1 +/- (v/c)]/[1-(v^2/c^2)]^{0.5} \approx\approx \{\{\upsilon\ [1 -/+ (v/c)]\} + \{\upsilon/[1 +/- (v/c)]\}\}/2 \qquad (15)$$

Presentations of SR that seek its cogency do not proceed as we have proceeded above. They argue, in fact, that SR's view of the Doppler is *not* in conflict with the classical approach. The curious built-in conditions that they present for a smooth extraction of the classical Doppler from the SR treatment are:

1. That we begin by accepting a 4-D Minkowski Space-Time map where worldlines can be inscribed with respect to an invariant c (in the vacuum, in the absence of a material medium for the propagation of light, when n=1 and thus c/n = c, and where no medium for the transmission of light appears to be needed).

2. That we apply to the first-order term the full formula for sound, but as a function of the speed c_m in a (material) medium, so that $c_m = c/n$ where n>1.

3. That the relativistic formula (with the first and second-order terms) be seen as directly deriving from the so-called "relativistic law of composition of velocities" (a law that is *properly* aetherometric, and which Relativity, for instance, *fails to correctly apply* to the determination of the resultant velocity for particles accelerated by an electric field, even in the absence of electrical collisions [23]).

So, a cogent treatment of SR begins by presenting the observed frequency υ' as a function which *already entails* a second-order correction with respect to the invariant c *in vacuo* when the motions of source and observer are distinguished with respect to a material medium where light presents an index of refraction, and thus a slowing down with respect to its invariant speed *in vacuo*:

$$\upsilon' = \upsilon \{\{[1 +/- (v_o/c_m)]/[1 -/+ (v_s/c_m)]\}^{1.0} \ \{[1 - (v_s^2/c^2)]/[1 - (v_o^2/c^2)]\}^{0.5}\} \quad (16)$$

Sound-like Complete Classical Doppler — 2nd order SR correction

Now the argument for the smooth evolution flows like this:

1. If the velocities v_o and v_s are very small with respect to c, we can neglect the second term entirely and use only the first as a suitable approximation, the SR function then reducing to the complete classical Doppler:

$$\upsilon' = \upsilon \{[1 +/- (v_o/c_m)]/[1 -/+ (v_s/c_m)]\} \quad (17)$$

Note, then, that the first term does not really result from equation 16; it simply becomes prominent if the second term is sufficiently close to 1.

2. If, on the other hand, the velocity of light c_m in the medium approaches the limit c *in vacuo* (when $c_m = c$) then the SR Doppler formula reveals the law of composition of velocities:

$$\upsilon' = \upsilon \{\{[1 +/- (v_o/c)]/[1 -/+ (v_s/c)]\} \{[1 - (v_s/c)^2]/[1 - (v_o/c)^2]\}^{0.5}\} =$$
$$= \upsilon \{\{[1 +/- (v_o/c)]/[1 -/+ (v_o/c)]\} \{[1 +/- (v_s/c)]/[1 -/+ (v_s/c)]\}\}^{0.5} \quad (18)$$

The square-rooted term in the second line of equation 18 expresses the Doppler shift exclusively as a function of the geometric-mean law of composition of velocities, where the resultant *relative* speed v (often written as u) between emitter and absorber varies according to this relation of velocity composition:

$$[1 +/- (v/c)]/[1 -/+ (v/c)] =$$
$$= \{[1 +/- (v_o/c)]/[1 -/+ (v_o/c)]\} \{[1 +/- (v_s/c)]/[1 -/+ (v_s/c)]\} \quad (19a)$$

Effectively, then, the relative speed v is *not* a classical addition of the two speeds v_o and v_s, but their sum (generally along an axis of a system of co-ordinates) with a second order correction:

$$v = (v_o + v_s)/[1 + (v_o v_s/c^2)] \quad (19b)$$

so that one arrives at the general formulation of SR's Doppler formula:

$$\upsilon' = \upsilon [1 +/- (v/c)]/[1-(v^2/c^2)]^{0.5} = \upsilon [1-(v^2/c^2)]^{0.5}/[1 -/+ (v/c)] =$$
$$= \upsilon \{[1 +/- (v/c)]/[1 -/+ (v/c)]\}^{0.5} \quad (20)$$

where, in the last term, we recognize the aetherometric formulation (see below) of what is, simply and effectively, an expression for the geometric mean of velocity differentials (with respect to the moving observer and the moving source) - and distinct therefore from their arithmetic mean.

It is worth remarking that, aside from the "generative definition" of v (with which Aetherometry disagrees, see [24] for a summary presentation), the formula that SR arrives at is exactly this (aethero-)geometric mean of two distinct but indistinguishable motions and, therefore, not the classical acoustical Doppler formula, either complete or (observer-)partial, as applied to light. Finally, the SR formulation does not permit one to extend the understanding of the Doppler effect to the Sagnac effect. There is no way, in fact, to obtain the first order effect from the above formulations, other than by 'a vanishing second-order term'. If the Sagnac were the result of motion relative to a medium, the motion of this medium should already be accounted for in the value of c_m, since this value would be equivalent, on one arm, to $c-v = c_{m1}$, and thus, in the oppositely directed arm, to $c-v = c_{m2}$; but these changes will not reduce the formula to the first-order effect. The SR explanation of the Sagnac, then, must neutralize or neglect the second-order term by a different method.

4. The light Doppler shift and Aetherometry

4.1. The apparent photon frequency shift is an indirect result of a local normalization by relay emission

Indeed, the formula that Einstein had introduced was tantamount to taking the geometric mean of the two motions - (1) with respect to the receiver, as if the receiver were stationary (ie divide by [1+/-(v/c)]), and (2) with respect to the emitter, as if the latter in turn were stationary (ie multiply by [1-/+(v/c)]). And, indeed, that is the aetherometric formula for the Doppler shift of linearly aligned ray-forming photons *with respect to the observer, as a function of the relative velocity between observer and emitter*, and *as normalized by* the collective and synchronous motion of a group of successive emitters/receivers whose field acceleration and deceleration vectors are substantially uniform and parallel. Thus we write the geometric mean of two superimposed motions (source and receiver) with the same relative velocity value, as:

$$\upsilon' = \{\{\upsilon\ [1 \mp (v/c)]\} * \{\upsilon/[1 \pm (v/c)]\}\}^{0.5} = \upsilon\ \{[1 \mp (v/c)]/[1 \pm (v/c)]\}^{0.5} \qquad (21)$$

This happens to give the same exact value as SR's formula for what is, in the aetherometric perspective, the apparent and observer-relative shift of the linear concatenation of photons released sequentially from decelerating charges *in vacuo*; but the aetherometric model shows, furthermore, that there is no real second-order effect, only the geometric mean of two distinct first order effects, ie the square root of their superimposition. In other words, it is the LF(Lorentz-Fitzgerald)-transformation that lacks an independent foundation, being just a possible *interpretation of* the law of composition of velocities - an interpretation which only in the case of SR (and not in the case of the Lorentz-Larmor relativity, LLR) appears at first to be indistinguishable from the correct result.

The aetherometric Doppler function for relative disjunction or separation involving 'uniform (quasi-)linear motion' then becomes:

$$\upsilon' = \upsilon\ \{[1-(v/c)]/[1+(v/c)]\}^{0.5} \qquad (21a)$$

and that for relative conjunction -

$$\upsilon' = \upsilon\ \{[1+(v/c)]/[1-(v/c)]\}^{0.5} \qquad (21b)$$

Aetherometry argues that c is referenced naturally to the inertial frame of the emitter, and thus that these formulas only apply to the motion of observers that do not share the inertial frame of the emitter, or to motions of the source and emitter relative to an inertial frame (eg of a material medium intervening in the concatenation of the ray) that neither one shares.

4.2. Where classical physics, SR and Aetherometry differ re. the light Doppler shift

We should note that, with respect to the wavelength λ of the source emission, only the classical Doppler formula yields the direct equivalences:

$$\upsilon' = \upsilon\ [1+(v/c)] = (c+v)/\lambda \quad (22a)$$

$$\upsilon' = \upsilon\ [1-(v/c)] = (c-v)/\lambda \quad (22b)$$

The equivalence of the first and last terms in each of equations 22a and 22b is not altered by SR, only the middle term in each equation. The corresponding SR formulas are:

$$\upsilon' = \upsilon\ [1+(v/c)]/[1-(v^2/c^2)]^{0.5} = [(c+v)/\lambda]/[1-(v^2/c^2)]^{0.5} \quad (23a)$$

$$\upsilon' = \upsilon\ [1-(v/c)]/[1-(v/c)^2]^{0.5} = [(c-v)/\lambda]/[1-(v^2/c^2)]^{0.5} \quad (23b)$$

which means that we obtain

$$\upsilon'\ [1-(v^2/c^2)]^{0.5} = (c+v)/\lambda \quad (24a)$$

for blueshifts, and

$$\upsilon'\ [1-(v^2/c^2)]^{0.5} = (c-v)/\lambda \quad (24b)$$

for redshifts.

As for Aetherometry (compare the second and fourth lines of Table 1), the two corresponding relations reduce to -

$$\upsilon' = \{\upsilon\ [1+(v/c)]\ \upsilon/[1-(v/c)]\}^{0.5} = [(c+v)/\lambda]^{0.5}\ \{\upsilon/[1-(v/c)]\}^{0.5} \quad (25a)$$

$$\upsilon' = \{\upsilon\ [1-(v/c)]\ \upsilon/[1+(v/c)]\}^{0.5} = [(c-v)/\lambda]^{0.5}\ \{\upsilon/[1+(v/c)]\}^{0.5} \quad (25b)$$

so that

$$\upsilon'/\{\upsilon/[1-(v/c)]\}^{0.5} = [(c+v)/\lambda]^{0.5} \quad (26a)$$

$$\upsilon'/\{\upsilon/[1+(v/c)]\}^{0.5} = [(c-v)/\lambda]^{0.5} \quad (26b)$$

and

$$\lambda = (c+v)\ \{\upsilon/\upsilon'^2[1-(v/c)]\} = (c-v)\ \{\upsilon/\upsilon'^2[1+(v/c)]\} \qquad (27)$$

Einstein saw the SR formula (see equation #20) for the Doppler shift of light as a consequence of an absolute normalization intrinsic to the nature of light 'transmission' with respect to interchangeable inertial frames, and a strict function of the relative velocity between emitter and receiver - not as a function of a medium intervening in the transmission of light. We suggest that the function (see equations #21, and #s 25-27) is, instead - as shown by the aetherometric formulation - the result of a physical process of energy normalization that occurs irrespective of whether there is an intervening medium, and regardless of whether it occurs *in vacuo* or through a material medium. The normalization is built (1) into the nature of the 'propagation' (because 'propagation', or better, concatenation of photons, involves sequential and alternating receiver and emitter functions in forming the path of a ray), and (2) into the nature of the emitter, as each emitter relays a photon that, with respect to the emitter's own inertial frame, always and only moves at c. Since the nature of the concatenation is that of a superimposition of photons (in Space and in Time), the geometric mean of the two functions (motion of observer and motion of source) is invoked by the very physics of the concatenation of photons into rays. Each ray-forming element, each photon fiber or, rather, globule, would *appear to expand or contract* in a particular direction as a function of the rate of expansion (lengthening) or contraction (length shortening) *of the distance between source and receiver*. It is this physics that seems to directly suggest, not that no medium can exist for light, but that no medium *need* exist, since all is in motion, the source and the receiver, and only their relative velocity matters for purposes of electromagnetic signaling between them.

The preceding seems to suggest, at first, that there is no way to use the Doppler shift of light to test Aetherometry - specifically, to distinguish it from SR. In fact there is; and this constitutes just one of the tests that permit us to distinguish between AToS and SR. But before going there (which is the subject of the next monograph in the present volume of AToS), let's examine another effect - the Sagnac effect - and its relation to the light Doppler shift, keeping in mind that in the latter there is an actual change in the length of the path of the 'transmission' caused by the differential of a relative velocity (a reciprocal state of motion), and that this changing path induces the apparent perception of an altered frequency that presents a *time measure* different from what the light really has at the source. The essence of the Doppler is the objective error of an appearance, but the changing distance between emitter and receiver is a physical reality. Is this what happens in the Sagnac effect? What is the relation between these two effects - Doppler and Sagnac?

5. Aetherometry vs Special Relativity: the Sagnac as a non-classical Doppler effect

5.1. Relativity and the Sagnac effect

When it comes to the SR formulation and the explanation it provides, there is no way that one can, without invoking some metaphysical particularity of rotation, consistently explain with its *armamentarium* the results of the 1913 Sagnac experiment [25-26]. Why does the Sagnac comply entirely with a first-order effect, and no second-order term must be invoked when there is rotary motion?

Because of the invocation of LF transformations to justify a second-order correction, SR could not account for the simpler, classical-like Doppler shift that appeared to rule the Sagnac. To account for it, Relativity had to invoke the General Theory (GR), and propose a different model for the behavior of light with reference to accelerated frames, in particular frames engaged in rotation [27].

5.1.1. Sagnac (in Relativity) referenced to the central, inertial frame of the rotating interferometer

Central to Relativity's argument that the Sagnac does not conflict with SR and is explained by GR is the demonstration that, when analyzed with respect to the inertial system of coordinates of the rotating interferometer, *each segment of the path between adjacent mirrors in a rotating platform is crossed in different times depending upon whether light traverses the segment in a co-rotating or anti-rotating direction*. Note that the origin of the inertial frame of the rotating interferometer lies at the intersection of the equatorial plane of rotation - the interferometer being treated as a spinning hoop with radius R - with the axis of rotation. The difference between the two times is regarded as the *time anisotropy* of each equal arbitrary segment of the perimeter of a rotating rim, and the ratio dt/dp (where dt is the difference between times of emission and reception and dp is the length of the segment) is:

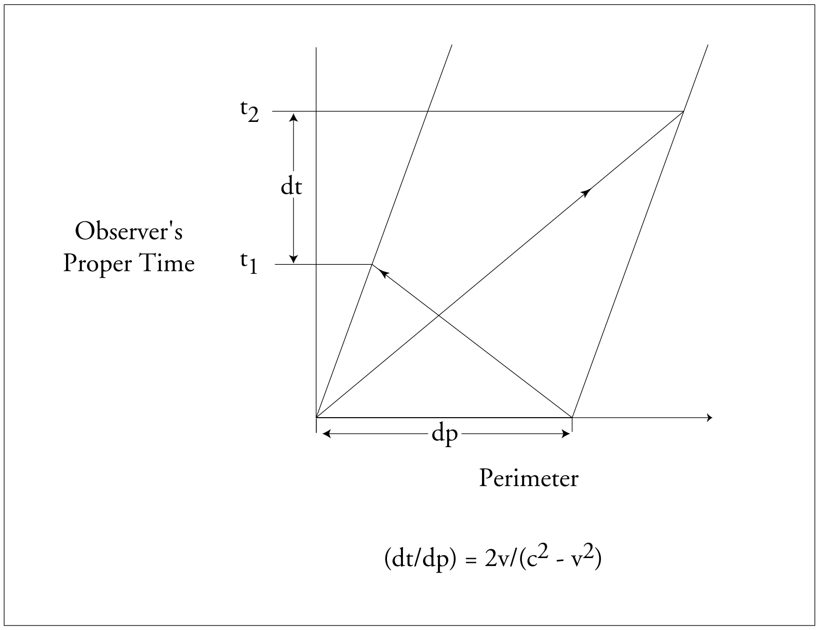
$$dt/dp = 2v/(c^2-v^2) \qquad (28)$$

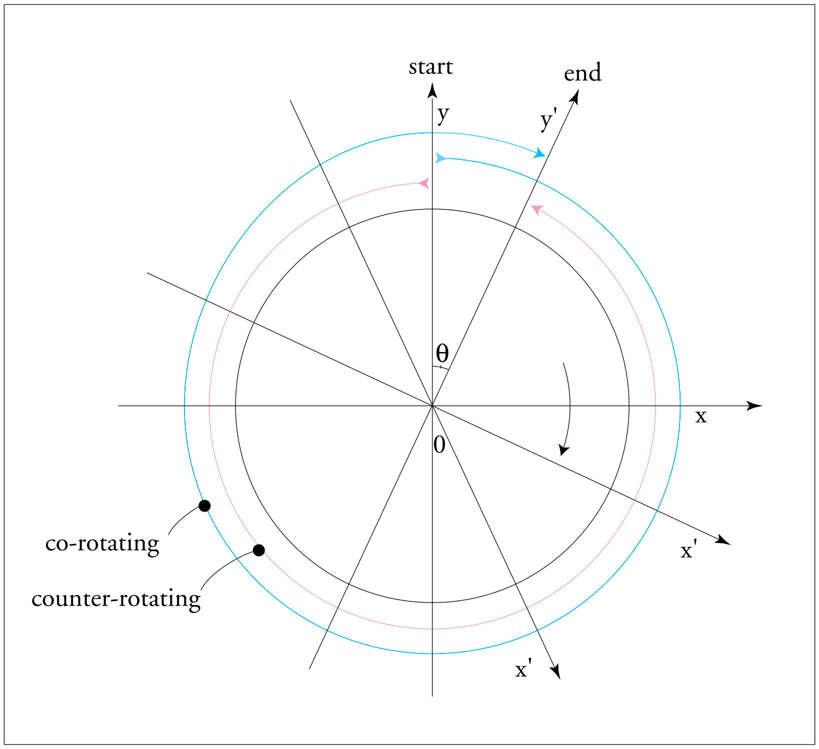
Integration of all the identical time differences for all of the segments generates the well-known Sagnac result that is proportional to the circumferential tangent speed, $v = R\omega$, of the rotating rim (and thus proportional to the area enclosed by the hoop):

$$T = \int_{p=0}^{2\pi R} [2v/(c^2-v^2)]\, dp = 4\pi Rv/(c^2-v^2) = 4A\omega/(c^2-v^2) = \Delta t = t_2 - t_1 \qquad (29)$$

From the viewpoint of the inertial axis of rotation the anisotropy is due to the fact that *the paths traversed by the two light beams are different* in size (see **Fig. 6**); the counter-rotating beam travels a short-

Fig. 6
Sagnac with respect to central internal frame of rotating Sagnac
(after Brown)





er distance, and so arrives earlier than the co-rotating beam [28]. In fact, the path of the counter-rotating beam is smaller than the circumference of the rim, and the path of the co-rotating beam is greater. The paths are only greater and smaller than the circumference of the hoop because in one direction light appears to propagate with an additional velocity v and in the other direction, with a velocity diminished by the same v.

The Sagnac anisotropic ratio is the ratio between travel times:

$$t_2/t_1 = (c + R\omega)/(c - R\omega) \tag{30}$$

An objection often made against this relativistic approach is that if only relative motion is determinant, there should be interchangeability between a treatment of the hoop in rotation, and a treatment that views it as stationary. If such interchangeability applied, then *from the perspective of any point fixed on the rim and arbitrarily chosen to be the locus of emission and end-point reception, the path travelled by the two oppositely directed beams would appear to be exactly the same - the very circumference of the rim - whether the hoop was rotating with respect to an axis-centered inertial frame, or stationary with respect to it*. Yet, in the Sagnac, a detector fixed to the rim of the rotating platform will experience a shorter time interval for the detection of the counter-rotating beam than it would if the the hoop is stationary - and a longer interval before the co-rotating beam is received. From the perspective of any emitter/receiver point fixed on the rim, the path might seem to be the same, yet the times of reception are different, and different because *the fixed point serving as emitter/receiver is moving with speed v towards the counter-rotating beam* (the equivalent of approaching a source), *and moving with the same speed in a direction parallel to*, *but away from*, *the co-rotating beam* (the equivalent of separation from a source). Since the times of reception are different, so are the paths traveled by the oppositely looped light beams. Thus, through the Sagnac effect, a rotating platform can detect its own rotation, and thus determine whether it is stationary or not, lending to rotation what appears to be an absolute character (a wheel rotating about an axis in space can determine its own state of rotation in an absolute manner).

5.1.2. Sagnac referenced (in Relativity) to the rotating frame of the rotating interferometer

However, according to Relativity, a clock attached to any point on the perimeter of the rotating hoop would not record the same time difference Δt as registered at the axis-centered inertial frame, but a time interval shorter by the second-order relativistic factor, ie given by

$$\Delta t /[1-(v^2/c^2)]^{0.5} \tag{31}$$

SR argues further that this is canceled out because the characteristic frequency of a light source co-moving with a clock fixed to the rim of the hoop would be comparatively greater - than the same frequency detected at the axis-centered frame - by exactly the same factor, *so that the two second-order Doppler shifts should cancel to present an invariant phase difference*. It would appear, therefore, that, according to Relativity, there is a second-order Doppler (or call it LF transformation) between axis-centered and rim-fixed clocks that is doubled up or *reciprocated* by another second-order frequency Doppler (or, again, an LF transform) such that they cancel out to leave the Sagnac effect 'untouched'. In fact, *this is all that SR adds to the Sagnac* - or just about all, since it is also said that "the [Sagnac] apparatus is set up as a differential device, so the relativistic effects apply equally in both directions, and hence the higher order corrections of SR cancel out the phase difference" [28].

Only with reference to a system of rotating non-inertial coordinates does GR acknowledge that the speed of apparent light propagation is *not invariant* and, further, that the spatial length of a path depends upon "the speed of a path" (whatever that is). The demonstration can be carried out within a cylindrical system of inertial polar coordinates in "2+1 Spacetime", with respect to which the spinning loop is considered to be stationary, and it shows that - with C denoting the non-invariant speed of light with respecting to rotating non-inertial coordinates, and S as a length integrating "the absolute spacelike differential using the metric along some constant-T surface" [29] (ie with dT=0):

$$C^2 = (dS/dT)^2 = 1 \pm 2v + v^2 = (1 \pm v)^2 \qquad (32)$$

where the changing sign denotes the direction of the light beam with respect to the direction of rotation of the hoop or an n-sided polygon. This demonstration is used by Relativity and relativists to argue both that (1) *the Sagnac is not reducible to the Doppler*; and that (2) the *non-inertial* "speed of light" (C, and not c) with respect to *rotating* coordinates effectively is not equal to c, without this creating a conflict with Special Relativity and the fact that the ratio of the speeds in the two directions remains (1+v)/(1-v) as measured by reference to *inertial* coordinates.

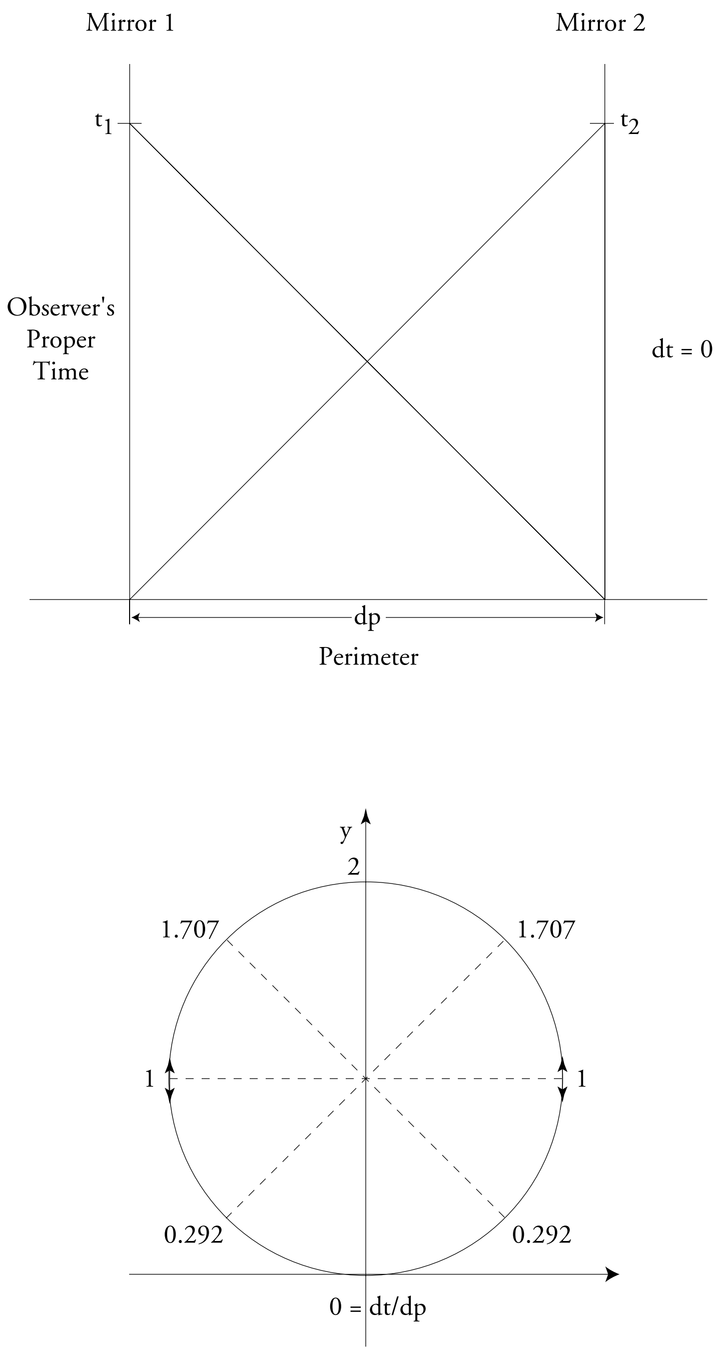
5.1.3. Sagnac referenced to an instantaneous inertial frame in SR

Now, Relativity points out that, if a parallel analysis is carried out for any point of the spinning hoop or polygon with respect to an inertial frame that is momentarily co-moving with one of the segments between adjacent mirrors, it is found that the difference between times is null (dt = 0) and no time anisotropy results (see **Fig. 7**). The inertial frame is supposed to momentarily reflect the tangential frame (of centrifugal escape) of a point in a segment (in practice the segment is treated as the point, and this can give rise to obvious objections).

However, this null time difference that is measured against an instantaneous inertial frame is not seen by SR as a contradiction or a negation of the Sagnac effect itself. For SR reminds us that with respect to the inertial frame at any tangent point, all other segments will present an angular variation of anisotropy, as a function of the angle θ of their position with respect to the arbitrary tangent

Fig. 7

Sagnac aniosotropy with respect to instantaneous inertial frame
(After Brown)



of reference:

$$dt/dp = [2v/(c^2-v^2)]\ (1-\cos\theta) \qquad (33)$$

such that the integration around the entire perimeter of all the anisotropies relative to that arbitrarily chosen inertial frame again yields the same Sagnac equation, or nonzero anisotropy for the two entire light 'transmission' loops:

$$T = \int_{p=0}^{2\pi R} \{2v\ [1-\cos(p/R)]/(c^2-v^2)\}\ dp = 4A\omega/(c^2-v^2) = \Delta t = t_2 - t_1 \qquad (34)$$

In this analysis, SR defines any point (or segment) of the periphery of the rotating rim as momentarily coinciding with an inertial frame at a tangent to that point. All the points on the rim share the same circumferential tangent speed, $v = \omega R$, but their velocity angularly varies with θ and so their simultaneous tangent inertial frames do not overlap.

5.2. False objection to the relativist treatment

A common objection to the relativist treatment of the Sagnac effect is that, if one supposes the speed $v = R\omega$ to be constant and one increases the radius of the rotating loop or polygon to the limit where it goes to infinity and the angular speed ω goes to zero, the rotating coordinates approach the instantaneous inertial coordinates, and yet the speed ratio would remain the same and thus apparent propagation of light in either direction would still occur with a speed other than c, but this time with respect to what would have become, effectively, an (instantaneous) inertial frame of reference.

The objection is not very convincing since, if the angular speed really went to zero or near-zero (a physical possibility - unlike the physical impossibility of the radius becoming infinite...), there would, by definition, no longer be a rotating frame of reference - only an inertial frame accompanying the now linear (or quasi-linear) escape motion of what was before an element of a rotating hoop or polygon that served as relay in a looped 'transmission' of light.

Since SR does not require the speed of light to be invariant with respect *only* to the inertial frame of the emitter *or to share the emitter's state of motion*, it could simply argue that, even for the case of the individual elements of a spinning circular fiber-optic, the proximal path of emission of light is always 'straight' or 'linear' in the instantaneous inertial frame of any co-moving point that serves as an emitter (and as a mirror in the relay of light around the rotating polygon). In the instantaneous inertial frame, the emitted light would form a straight ray lying along the tangent to a point [**Fig. 8A**] or, better, lying along the straight line between any two vertices of the polygon, on the inside of the rotating polygon or hoop [**Fig. 8B**]. Then, for as long as the angular speed still had some effec-

Fig. 8A

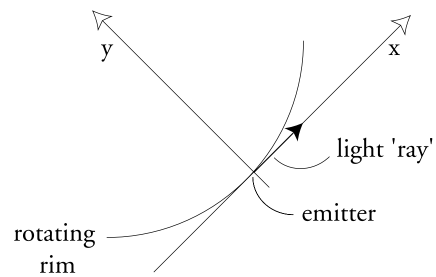
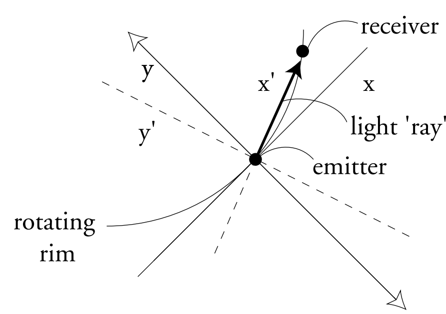


Fig. 8B



tive value, no matter how small - and thus for as long as a radius, no matter how large, effectively existed for such a motion - there would still be an angle, no matter how small (*clinamen*), between the quasi-linear trajectory of a light ray emitted by a rim element of the rotating loop or polygon and the trajectory of that element in its rotary motion, or the motion of its non-inertial rotating frame. As long as there is an angular travel of the hoop or polygon, or of any solidary element of it, there will be a ratio of different times and a propagation speed other than 1 in the relay that concatenates photons in one loop or the other.

Relativity acknowledges this situation of the problem by proposing a much more sophisticated analysis, under the rubric, not of Special, but of General Relativity, where light is warped as a function of the shape of the path and the speed of the rim enclosing a loop or an n-sided polygon. In this analysis, the co-rotating beam travels *inside* a rotating n-sided polygon, first curving in towards the center and then curving out to the next adjacent mirror, and so on - while the counter-rotating beam travels *outside* the polygon, first curving out and then in, and so on [30].

However, despite being unconvincing, the above objection to SR illustrates, by default, the fact that for a light-relaying element of a rotating rim, no real linear motion exists, no real tangential inertial frame that is instantaneous, only a virtual one; effectively, when such a frame appears to become actualized by a motion - of such an element - having an *actual escape velocity*, it already subtends or requires a changing relationship of force and energy that engages still another angular motion (and, in reality, the radius varies without ever having to reach infinity as a limit). In a real sense, for an element on the rim of a rotating polygon there is no linear escape from an angular trajectory, without that element thereby already becoming engaged in the rim of some other rotating 'polygon'. Hence, aetherometrically, an effective tangential motion can only be the manifestation of another rotary motion about a different center, and no more or less inertial than the original rotation of the escaped element.

5.3. Renshaw's failed demonstration that the Sagnac is not reducible to the classical Doppler

It is interesting to note that the scenario of the above, not very credible, objection often made against Relativity, is also employed to (supposedly) demonstrate that the Sagnac is *not* reducible to the *classical* (observer-partial) light Doppler model.

Again, let the radius of the hoop (or polygon or cylinder) approach infinity and the angular speed approach zero, while the velocity v is kept constant. The argument now runs as follows: at the limit, any two adjacent mirrors will have the same instantaneous velocity referenced to a tangential inertial frame that they can now share and yet the ratio of the two speeds of apparent propagation in opposing directions, (1+v)/(1-v), will remain different from 1 (different from c). This is proof that, since they now share the same velocity vectors with respect to the same instantaneous inertial frame and yet the speeds of apparent propagation differ from c, there is no relative velocity change between emitter and receiver that can be invoked as the cause of the Sagnac, and thus the Sagnac cannot be explained by the Doppler [31].

This is a gigantic misunderstanding, for two main reasons:

1) At the risk of repeating ourselves, once the angular velocity of a segment, no matter how infinitesimal, between two adjacent mirrors goes to zero, there is at any point, or segment, on a rim no more tangential velocity that may effectively be contributed by rotation with respect to an axis-centered inertial frame - and no more looping either of the light 'transmission' paths in directions diametrically with respect to the direction of that rotation.

2) Then, once two adjacent elements engage in a shared (quasi-)linear motion with constant

velocity while maintaining constant linear distance between them, the Sagnac effect disappears (since it is relative to the differential between the motion of the emitter/detectors and the apparent speed of 'transmission' of light in oppositely directed loops). Instead of measuring variable light loop 'transmission' velocities, it will now measure an invariant linear transmission velocity of light given that the two adjacent elements whose motion was linearized share the same state of motion and thus the same inertial frame. So, if the demonstration is to be taken seriously, as the Sagnac effect disappears when angular velocity goes to zero, so does any Doppler - which becomes effectively precluded in any of its actual or even conjectured forms, classical included. All the demonstration achieves is to show that when the Sagnac disappears, there is also no Doppler left...

Aetherometrically, and in the literal sense of the reduction, *the Sagnac is indeed not reducible to the linear* (or transverse) *light Doppler*. In fact, *the Sagnac appears to be coincident with the classical light Doppler*, *specifically the observer-partial form*; but the classical light Doppler, in either of its two forms, complete or partial, does not really account for what it is supposed to account for (what it was enunciated for), ie how the perception or detection of light varies with the observer's (quasi-)linear relative velocity with respect to a source that emits (quasi-)linear light rays (or originates the photon emission that gets linearly concatenated into a ray), whether the source is co-moving, counter-moving or neither. The results of the actual Doppler that operates under these conditions can be phenomenologically obtained, instead and as we have seen above, with the SR light Doppler formulation. *Moreover*, *none of this precludes the Sagnac from being simply a variant*, or a different form, *of the Doppler effect*. In the same way that the linear light Doppler is a derivative of the geometric composition of velocities that appears to phenomenologically coincide with SR's theory of a second-order term required by the LF transforms, so could the Sagnac effect and its amalgamation to a first-order, classical, observer-partial Doppler be *but a derivative of the same geometric law for a more complex composition of velocities* (the simplest is also the most complex). In fact, it turns out that this is precisely the case.

5.4. Aetherometry's difference from Relativity with respect to the Sagnac

Aetherometry agrees with much of Relativity's approach to the Sagnac. (1) There is a time delay registered in a rotating frame with respect to the direction of apparent light 'transmission' in co-rotating and counter-rotating light loops (see **Fig. 6**); and (2) there is no time delay registered in an instantaneous inertial frame coincident with the tangent velocity of any point on the rim or polygon, but *the distribution of all the angular velocities around the rotating rim is anisotropic when considered from the perspective of any momentary inertial frame* (see **Fig. 7**). However, Aetherometry notes the "sleight of hand" that creeps in with respect to the feature 1, since *time delays are registered not just in the rotating frame* - which itself is a function of rotation with respect to an axial-centered inertial frame - *but also in the axial-centered inertial frame, which is irrotational.* With respect to feature 2, Aetherometry notes that the absence of a time delay in any arbitrary, instantaneous, tangent inertial frame only confirms the aetherometric contention that c as a wavespeed of photons is always invariant with respect to the inertial frame of the local photon emitter.

Keeping these provisos in mind, let's revisit the basics of the Sagnac. Consider a hoop that is *stationary* about its center and any other arbitrary axis in its neighbourhood. Let a point fixed on the rim emit light in both directions and loop its path through a series of adjacent mirrors back to the emitter which also serves as receiver. Beams emitted simultaneously in either direction will arrive simultaneously at the emitter/receiver. Light rotates around the hoop in opposing directions and arrives back at the source *with the same speed and in the same time interval*, having 'traveled' identical paths. Since all mirrors are stationary with respect to the emitter, and the hoop is stationary relative to its neighbouring space, the inertial frame of any point on the rim of the hoop is shared by all the points on the rim.

Now set this *hoop in motion* about an axis that cuts through the center of its plane. Since all the points on the rim remain solidary, *they share the same rotary motion about the inertial center while keeping their distances constant with respect to the moving platform and to one another, but they no longer share any inertial frame on a tangent to any of them*. It is only with respect to the axial inertial system that all points on the rim share the same motion and inertia. In other words, once the hoop is in rotation, one cannot define common inertial coordinates for all points or segments on the rotating rim. *Any common coordinates that would be rigidly attached to the rotating rim would be not inertial but accelerational* (rotational), *and SR does not require invariant or isotropic light transmission with respect to non-inertial coordinates*. However, despite SR's contention of different clock values, a time difference is observed with reference to either the axis-centered clock of the inertial frame of the whole rotating hoop, or to a clock fixed to its rim; and, whereas the latter is referenced to a non-inertial rotating frame, the former *is* an inertial frame, and with respect to inertial frames both *Einstein's SR and Lorenz's relativistic theory require propagation of light at a speed that remains invariant and independent from the state of motion of the source. Thus, a contradiction appears to creep in this respect*.

Manifestly, *with respect to the inertial frame of the whole hoop* - once the hoop is in rotation - the speed of apparent light 'propagation' *does vary*. So it would appear that it varies not just with respect to the non-inertial rotating frame of any and every point attached to the rotating rim, *but also with respect to their common inertial frame*. In fact, this is the reason why the Sagnac effect can be detected in the laboratory frame, since the original emitter and the end-point detector are anchored together to the laboratory frame, where the axial-centered inertial frame of the rotating interferometer is also at rest.

But then it would seem that the speed of light is not even constant with respect to the source, specifically if an emitter is in a state of rotational motion. Is this correct? No, not really. In fact, that is *precisely the point of the demonstration* that, *with respect to any instantaneous co-moving inertial frame for any point on the rotating rim*, the time delay of the transmission with respect to its *most proximal* *or actual* emitter *appears to be zero* and the speed of light *remains invariant in the emitter's inertial frame*. Indeed, it is only with respect to any such arbitrary point that c is invariant - and, since these instantaneous inertial coordinates are not those simultaneously shared by any other point on the rotating rim, the apparent speed of light around the 'transmission' loop *with respect* to these *arbitrary inertial coordinates* is not c at those other points (thus the total nonzero anisotropy for the entire loop). In other words, *it is the relative speed of concatenation of photons around a loop that varies - without the wavespeed of each photon with respect to the inertial frame of its emitter having to vary*.

Precisely the difference between (1) experiments employing detection of linear light 'transmission' - whether source and observer share the same motion and the same inertial frame (as in the Michelson-Morley experiment), or are instead in relative motion (as in the linear Doppler shift) - *and* (2) experiments like the Sagnac which, instead, employ looped light 'transmission', *is that only by virtue of a differential 'transmission' loop can an emitter detect its own state of motion*. In the absence of a light loop feeding the detection back to an emitter that serves as its own detector, all that any detector can do is perceive with or without 'distortion' (frequency shift) a signal that *either reports no relative motion* ('undistorted' signal, and thus invariant 'transmission' velocity) *or only reports relative motion between distinct emitter and receiver elements* ('distorted' signal), without being able to discriminate whether one or the other moves, or both do.

In the Sagnac, the detector or observer is made, by design and thus per force, solidary with the emitter or source, and thus the transmission has to be made in *a loop that returns to the emitter*. In any instantaneous inertial frame of a source, the light emitted is emitted at speed c. But *a medium composed of many receivers and emitters in turn must intervene to relay the signal in a looped path that returns it to the source*, revealing to the source the speed of the latter's own motion and its direction with respect, precisely, to all the possible locations of all possible relay mirrors/emitters in the feedback path, and thus with respect to the speed of light in its own frame as emitter, or 'seized' in the proper inertial frame of every other relay element treated as emitter (ie 'instantaneously seized' at the time of its relaying emission).

Thus, it is with respect to the differential between (1) the angular motion of all solidary elements of a rim rotating about an inertial center, and (2) the looped apparent motion of light in antipodal directions, that the "start-point" emitter measures its own relative state of motion - being an observer relative to itself as source in a given state of motion that it, observer, can measure against the normalized speed of light in its own inertial frame of reference. And this measure made in the rotating frame is, in fact (and despite SR's claim of a reciprocal clock/frequency dephasing), the same measure one obtains at the intersection between the axis of rotation and the plane of rotation of the n-polygon, ie in the inertial frame of the *whole* rotating system of light-relaying elements.

5.5. The aetherometric treatment of the Sagnac as an angular Doppler

Thus, in the Sagnac, all happens fundamentally as with the linear light Doppler, but with a difference - the very difference that permits the classical observer-partial light Doppler to appear to apply to the Sagnac, when it does not apply to the linear light Doppler it was supposed to explain.

The difference is a compound one.

1) On one hand, the source is also the observer, but it is first a source and then, after a lapse of time, becomes the observer. It is through time that the source relates to itself as a detector of its own state of motion. As a *source* and with respect to the light loop, it moves *towards a receding detector* in the *co-rotational* direction [32], and *towards an approaching detector* in the *counter-rotational* direction. As a detector, it is a split observer that at once *moves away from an approaching source* in the *co-rotational* direction, and *towards an approaching source* in the *counter-rotational* direction. Thus, *as in the actual linear light Doppler*, as well as in the classical observer-partial Doppler, *the light path physically increases or decreases as a function of the relative velocity of separation between source and observer(s)*. Consequently, the mean of the two differences remains invariant, or c:

$$[(c-v)+(c+v)]/2 = c \qquad (35)$$

So, in a very real sense, the Sagnac is a (kind of) Doppler measured against the invariant c = 1, such that this invariant applies either in the inertial frame of any emitter, or in the inertial frame common to all elements of a polygon, etc, engaged in coherent rotation. Since the mirrors are fixed to the rotating platform, the path of the co-rotating beam is functionally equivalent to a separation of source and observer - ie to a path lengthening as a function of their relative velocity v - whereas the path of the counter-rotating beam is functionally equivalent to a conjunction of source and observer - ie to a path contracting again as a function of their relative velocity. Thus, *while is often said that the Sagnac cannot be explained by the Doppler, the paths traveled by the electromagnetic signals in both effects either extend or contract as a function of a relative inertial velocity*. The difference is that, in the *linear light Doppler shift*, the paths are longer or shorter (than they would be if distinct source and receiver elements shared the same linear motion and thus kept their distance constant) solely as a function of the relative velocity of the source and receiver, whereas the Sagnac effect cannot be entirely accounted for solely by this function for their relative velocity. When source and receiver functions are solidary (and thus co-moving) in the same moving element, and light 'transmission' is made to loop in either direction (co-moving and counter-moving) with respect to their motion, as in the Sagnac effect, the reference is effectively the relative velocity difference between (1) the apparent propagation of light (ie $C \neq 1$) in either looped direction with respect to the rotating frame, and (2) its invariant 'linear' value (c =1) in the instantaneous inertial frame of any emitter/receiver; so that

$$C = c \pm v \tag{36}$$

In other words, the Sagnac is, *de jure* and *de facto* an *angular light Doppler shift*. The distances between adjacent elements engaged in a common frame of rotation can be kept constant, and each emitter-receiver can form a solidary element, because what each is measuring - or can measure - is its rotary motion relative to the differential of the apparent loop 'transmission' velocity of light in opposing directions.

2) This brings us to the other component of the difference - that, on the other hand, there is a third (really, a *fourth*) *term* which the Sagnac invokes besides just *the source, the observer and their relation*. The geometric mean composition cannot simply operate on the basis of the source and observer velocities. The relation between them is itself mediated by a light beam that loops or 'rotates' in the same or opposite direction of the rotation of a coherent collectivity of relaying elements. In fact, the Sagnac forces us to think through the role and definition of *a medium* in the 'propagation' of light. Light does not *need a medium for its transmission*, but *requires one for coherent concatenation of photons*, whether linearly or angularly. The medium needed for photon concatenation is not the Aether, but a *material* one; it is in fact *composed of the collectivity of receivers/emitters that coherently relay the repeated expression of the same or modal photon*, whether in the same place as a function of time, or at different times as a function of space. The light emitter is always in a state of motion - since reception of the signal imparts energy to the receiver, and no emitter can emit other than from a state of 'possession' of a kinetic energy that it is about to whittle away through the emission. A collectivity of relay emitters that share the same state(s) of motion, even *in vacuo*, is always needed to relay a near-continuous distribution of the light 'points' that form a ray, whether the distribution is formed linearly or angularly. What one terms the rotating or counter-rotating light loop is precisely that collectivity together with their 'light-relation', ie together with the photons they sequentially re-emit and intersect coherently, ie together with the relative motion of these photons or their beams. In other words, to say "that collectivity of intervening emitters" is effectively the same as saying "that light beam or light loop that does not share the instantaneous inertial frame of any of its emitter elements", or of any given arbitrary element; and, we emphasize, it is also the same as saying "that material medium with associated photons which is in motion between source and detector". With this in mind, we must ask - what does the Sagnac look like from the viewpoint of this "moving (rotating) material-photonic medium", from the viewpoint of this rotating loop of light, from the viewpoint of *the collectivity of all emitters but one* (any arbitrary start- and end-point emitter/receiver)?

In the instantaneous inertial frame of each relay emitter, lightspeed is invariant, but the loop as a whole does not appear to be moving at that invariant speed (from the perspective of that frame), but faster or slower, according to whether the loop counter-rotates or co-rotates. However, the emitter elements of the loop (note that they are emitter elements 'in time', ie momentarily in a sequence) are themselves anchored (their condition in space) to the rim of the rotating hoop or polygon, and thus either relay forward or backward with respect to their own fixed angular motion according to the (rotary, or concatenate) orientation of the light loop. All happens in the Sagnac as if there was also a moving medium *of Matter and photons* between a solidary moving source and moving receiver. When source and receiver approach (co-rotational direction), the conjunction involves some recession as if a medium expanded (recoiled) a little to counteract their approach, making the short path a little longer than it would be if the linear light Doppler applied to the Sagnac. And when source and receiver recede from one another (counter-rotational direction), the disjunction involves some advancing of the loop, as if a medium contracted (coiled in) a little to counteract their separation, making the long path a little shorter than it would be if the linear light Doppler fully applied to it. It is this reality that GR approximates by claiming that the co-rotating beam is 'warped' to travel inside, and the counter-rotating beam outside, the rotating polygon.

So, let's recapitulate: relative to the axis-centered inertial frame, any arbitrary start-point emitter (the source) is in motion. Relative to the same frame and to the source as well, the split observer, or the two observers (moving in opposite directions), are also in motion. So there is motion of the source with respect to the observers, and of the observers with respect to the source, and it is this motion that presents paths of different lengths. Hence, at a minimum, a light Doppler identical to the linear one must be at work. For relative motion with respect to 'linearized' distance(s), we have already established that a conjunction (or the shorter path) entails *a geometric mean composition of source and observer velocities along the shortest path between them*. Accordingly, the first modifying Doppler term is:

observer approaching — source approaching

$$\{[1+(v/c)] / [1-(v/c)]\}^{0.5} \tag{37}$$

However, as such, this term of the linear light Doppler does not account for the looped 'transmission' of light. The problem is that, in the angular conjunction of the Sagnac, the source that approaches the observer in the counter-rotating arm is an apparent one (a moving image of the source) - the light beam or loop; it is *the light loop that approaches the observer* or that which the observer approaches, whereas the *real source* is *receding* from the apparent one. The real source recedes from the counter-rotating beam, the very beam that to the end-point observer appears as source. *The overall beam itself is in accelerated motion* - as we saw above, when we examined it precisely and properly by reference to any instantaneous linear inertial frame.

What happens at any moment in time when we take on any instantaneous perspective of the looped light beam itself, *the perspective of the moving medium* - ie of the light loop with its momentary system of mediating, coherent emitters? The actual source appears to recede from it, while the observer appears to be moving towards it. Since an observer moving towards it, from its own 'medium' perspective, cannot be expressed mathematically other than by a term identical to that applied to a source moving towards it, the two motions experienced by the light loop combine to yield the loop's second modifying Doppler term; from its own perspective, we have:

actual source receding from apparent source	actual observer approaching apparent source

$$\{[1+(v/c)] \ * \ [1-(v/c)]\}^{-0.5} \qquad (38)$$

Now, the Sagnac effect refers to the end-point observer's perspective, whether that end-point observer is an arbitrary 'double' mounted on the rotating interferometer (and therefore the perspective will be that of a rotating frame), *or* an end-point observer in the axis-centered inertial frame. Accordingly, the perspective of the beam must be referred - in the form of the reciprocal - to the perspective of the end-point observer, to yield the first-order term of the classical observer-partial Doppler and show, in the process, how it is actually arrived at when it appears to apply to the Sagnac, *without having to invoke any arguments about vanishing or canceling second order terms*:

$$\{[1+(v/c)]/[1-(v/c)]\}^{0.5} \ / \ \{[1+(v/c)] * [1-(v/c)]\}^{-0.5} = [1+(v/c)] \qquad (39)$$

Effectively, it is as if the material medium's action in the angular concatenation of photons normalizes the Doppler shift in the Sagnac to the value of the classical linear Doppler, precisely when the Doppler involved is angular and not linear!

So far, the aetherometric approach has shown that there is no need to invoke LF transformations, not even a second order term, in order to arrive at the correct linear Doppler shift of light, anymore than there is a need to invoke a becoming-negligible of the second-order term in order to arrive at the Sagnac result (or, for that matter, to arrive at the incorrect, classical, observer-partial, linear Doppler that appears to coincide with the Sagnac, but cannot account for it anymore than it can account for the linear Doppler shift).

In fact, the aetherometric approach turns the tables on Relativity - for, as we shall now see, not only there is no second-order term that becomes negligible when a first-order result obtains or is obtained, but the obtention of that first-order factor is precisely what actually invokes a second-order term, that is, if there was such a term and not just the law of the geometric composition of velocities at work. Indeed, it is easy to show that, if to the linear light Doppler term for a conjunction we couple the relativistic (SR's) factor for the second-order term, we obtain:

$$\{[1+(v/c)]/[1-(v/c)]\}^{0.5} / [1-(v^2/c^2)]^{0.5} = [1+(v/c)] \quad (40)$$

The result is exactly the same - as it should be, precisely because the geometric mean of the velocities affecting the light loop, from its own perspective as a rotating frame (co- or counter-) in its own right, is equivalent to a second-order term:

$$\{[1+(v/c)] * [1-(v/c)]\}^{-0.5} = [1-(v^2/c^2)]^{-0.5} \quad (41)$$

Thus, it is when the first-order effect (the Sagnac as an angular Doppler) is produced that a second-order term must be introduced ("comes into play"), and *not* when it must vanish! It is the Sagnac that requires the introduction of a second-order term associated with the moving light loop, not the Sagnac that must be explained by cancellation of the second-order term or its vanishing.

Lastly, it is this physical reality of the affair that GR misunderstands when it tries to grasp it by saying that a clock in the rotating frame of the hoop's or n-polygon's rim will be slower than a clock placed in the axis-centered system by precisely this apparent second-order factor. GR fails to distinguish exactly where this clock lies - in the rotating frame of the relaying emitters anchored physically to the rotating hoop or polygon, as part of the hoop or polygon? Or in either of the rotating frames of the light loop itself, including its momentary and mediating emitters?

It is only from the perspective of the light loop that the frequency shift is *like* a second-order effect,

$$\upsilon_{loop} = \upsilon \{[1+(v/c)] * [1-(v/c)]\}^{-0.5} = \upsilon [1-(v^2/c^2)]^{-0.5} \quad (42)$$

and thus, only for that rotating frame will "a clock show a different time", or better, the frequency shift not be the full angular shift of the Sagnac.

Of course, we can make formal matters much simpler by just saying that, for a concatenating medium that is receding from the source, we will write as for the receding observer in the acoustic Doppler, a function of $\upsilon [1-(v/c)]^{0.5}$; and for the observer approaching the medium, we will write a function of $\upsilon [1+(v/c)]^{0.5}$. Accordingly, for the conjunction responsible for the shorter Sagnac path we will write:

$$\upsilon' = \upsilon \{[1 + (v/c)]/[1 - (v/c)]\}^{0.5} \{[1 + (v/c)] [1 - (v/c)]\}^{0.5} = \upsilon [1 + (v/c)] \quad (43)$$

where the first order Doppler is seen to result in the Sagnac without any vanishing of any term. For the disjunction, and the lengthening path,

$$\upsilon' = \upsilon \{[1 - (v/c)]/[1 + (v/c)]\}^{0.5} \{[1 - (v/c)]\ [1 + (v/c)]\}^{0.5} = \upsilon\ [1 - (v/c)] \quad (44)$$

The net effect of the medium (of *Matter and photons*) is to appear to cancel the relative motion of the source and receiver, contracting the disjunction and expanding the conjunction.

5.6. The inconsistencies of Larmor-Lorentzian Relativity

Other theories - such as Larmor-Lorentzian Relativity, Gagnon et al's Generalized Galilean Transformation (GCT) [33], or more recently, Gift's variation of the same [34] - invoke the discrepancy of the Doppler shift of light with respect to the classical formulas (see **Table 1**), not to deny the existence of a preferred frame (in eg 'absolute space'), but to assert it as proof of the existence of a medium for the transmission of light. Such theories claim that the stationary Aether of XIXth-century physics should be restored, and that proper application of the LF transformations precludes SR and its linear Doppler theory. In essence, these Lorentzian theories claim that a moving observer approaching a stationary source (and *mutatis mutandis* for a receding observer) measures a light frequency given, not by

$$\upsilon' = \upsilon\ [1+(v/c)] = (c+v)/\lambda \quad (22a)$$

but by

$$\upsilon' = \upsilon\ [1+(v/c)][1-(v^2/c^2)]^{0.5} = [(c+v)/\lambda]\ [1-(v^2/c^2)]^{0.5} \quad (45)$$

because the 'true frequency' in the preferred stationary frame should be:

$$\upsilon_a = \upsilon' /[1-(v^2/c^2)]^{0.5} = \upsilon\ [1+(v/c)] = [(c+v)/\lambda] \quad (46)$$

The argument boils down to an employment of the famous second-order term as multiplicand rather than as denominator - as it is employed in SR - when describing the frequency measured for a conjunction between observer and source. Of course, this employment does not have the simple virtue of SR's approach, since *it is simply inconsistent with the law of geometric composition of velocities*. Moreover, it must postulate - in order to explain the 1938 Ives & Stilwell experiment (see the next monograph in the present volume) - that, conversely, a moving light source with frequency υ will have a reduced frequency υ_a once it becomes stationary in the absolute preferred frame:

$$\upsilon_a = \upsilon\ [1-(v^2/c^2)]^{0.5} \quad (47)$$

Insofar as it is supposed to apply to the Ives & Stilwell experiment, this obviously relies on a mischaracterization of an inertial frame in which a source is at rest, as a stationary state deemed to have an absolute value in the preferred frame of a 'luminiferous' Aether. But, as follows from the above presentation of the aetherometric approach to linear and angular Dopplers, if anything, Aetherometry gives reason to Einstein's Special Relativity over Larmor-Lorentzian Relativity, but this is so simply because the aetherometric approach to the *two* light Dopplers yields results that are numerically identical to those of Einstein's Relativity (or, at least identical, in the absence of collisions *and if* the latter were to make the correct computations of the velocities of emitters, which, according to Aetherometry, it does not [33]), and not to those of Larmor-Lorentzian Relativity. However, the aetherometric treatment does not invoke any relativistic transformations (Einstein-Lorentzian or Larmor-Lorentzian) - and thus no real second-order effect - and this becomes clear in the aetherometric treatment of the Ives & Stilwell experiment, which is often called 'a verification of Time-dilation' by both parties of relativists (Roberts calls it a test of Time-dilation and the transverse Doppler effect [35]). In that novel treatment, we shall see how the aetherometric prediction is *significantly and substantially closer to the experimental results* than are the predictions of Einstein's Relativity or Larmor-Lorentzian Relativity, permitting us, therefore, to provide a remarkable experimental confirmation of Aetherometry as opposed to Relativity in either of its two forms.

Conclusion

In the preceding, we laid the basis for an aetherometric theory of the emission, transmission and distortion of electromagnetic signals between emitters and receivers in relative states of motion. We present a formal method based strictly upon the law of geometric mean composition of velocities to arrive at the same results that SR obtained for the *linear light Doppler* without invoking a second-order effect, and do likewise for the Sagnac effect to demonstrate the latter is nothing other than an *angular light Doppler* where a 'light loop' is also set in (apparent) motion.

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21. **See, in particular, p. 137 of French, AP (1966) "Special Relativity", WW Norton, NY.**

22. **Idem, pp.134-137.**

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26. **Sagnac, MG (1913) "Sur la preuve de la réalité de l'éther lumineux par l'éxperience de l'interférographe tournant", Comptes Rendus 157:1413 (December 22).**

27. The Sagnac experiment was fundamentally shunned by all 'general relativistists', and never treated in a systematic way. The Sagnac experiment is seldom mentioned in relativity textbooks. Sklar, whose seminal book "*Space, Time and Spacetime*" delves in detail on the absolute vs relative character of rotation, does not mention it once (French, as already noted, has the excuse that his course on interferometry only dealt with SR or the Michelson-Morley type of experiments). Clifford Will in his "*Was Einstein right?*", also does not mention it once, even as he argues (pp 217-218) that it was only after Dicke's approach to gravitation in the early 1960's - which was based on scalar-tensor theory - that rotation lost the absolute character that it had in Einstein's GR (and in Newton's theory of gravitation). Allan et al (*Science* (1985) 228:69) were the first to observe the Sagnac effect with GPS satellite signals.

28. K. Brown's rebuttal of naive aether theory apologists relies upon this fact, and so does his distinction of the Sagnac from the (transverse) Doppler. Brown's web-based presentation of SR and GR is by far the clearest and most systematic we have encountered. See **Brown, K (no date given) "Reflections on Relativity", section 2.7, "The Sagnac effect", at www.mathpages.com/rr/s2-07/2-07.htm**

29. **Brown, op. cit., Section 4.8, "The breakdown of simultaneity" at: www.mathpages.com/rr/s4-08/4-08.htm**

30. For a complete analysis the reader is referred to K. Brown's presentation in **section 5.1, "vis inertiae", at www.mathpages.com/rr/s5-01/5-01.htm**

31. **Renshaw, C (no date given) "The rotating interferometer, response to Robert Driscoll" at http://renshaw.teleinc.com/papers/drisco/drisco.stm . Renshaw calls this "the thinking man's proof" that the Sagnac is not explainable by the Doppler.**

32. Or, if light only propagated linearly with respect to instantaneous inertial frames of reference, one could say that, as a source, it finds itself in a state of motion that constantly diverges (for as long as angular speed does not go to zero) from the linear, or quasi-linear path of the emission it sourced.

33. **Gagnon, D et al (1988) "Guided-wave measurement of the one-way speed of light", Phys Rev A, 38:1767.**

34. **Gift, S (2006) "The relative motion of the Earth and the Ether detected", J Sci Exploration, 20:201.**

35. **Roberts, T (2000, 2007) "What is the experimental basis of Special Relativity?", at math.ucr.edu/home/baez/physics/Relativity/SR/experiments.html**