Questioning the Relativity of Inertia and Gravitation

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Assuming that the *Fitzgerald-Lorentz length-contraction* and the *Lorentz slowing of all electromagnetically-determined clocks* are real phenomena, one concludes that the relativistic Fitzgerald-Lorentz invariance *is proper, exclusively, to electromagnetic* systems. It is a theorem that may not be extended – *with an 'a priori' absolute certainty* – to systems containing inertial and/or gravitational active elements. That limitation is a draw-back of the fact that neither inertia nor gravitation was, until now, experimentally checked on a possible Fitzgerald-Lorentz invariance. At this aim two sorts of experiments – one determined by gravity and inertia, the second by inertia alone – are suggested and theoretically investigated by computational modeling. Quantitative results are worked out via finite difference approximation run in Excel programs.

1. Introduction

In desire to understand how our Universe works, a theoretical model – hypothetically based on the belief of a really-existing and everything-permeating fluid ether – was suggested in reference [1]. One assumed that inertia and gravitation govern the aggregate matter comportment in relation with the surrounding ether, while electro-magnetism runs in the classically known way **on** that medium. One also assumed that matter, at the macroscopic level, aggregates on basis of electromagnetic links**;** an assumption which implies that the Fitzgerald-Lorentz contraction of matter as well as the Ives-Stilwell slowing-down of all electromagnetic oscillators compulsorily follows.

In that way of thinking the theory of relativity comes out as a useful means of investigation nature's phenomena via Lorentz's coordinate transformation, understood *as a conformal-representation facility*.

On that line of thought, the present essay tries to find out, by theoretical means, if inertia and gravitation should be, both, Lorentz invariant phenomena, or independently different.

In [1] one assumed that gravitation may be intuitively imagined as the interaction of matter with the flow of ether configured by its inflow – in a well determined mode – in matter itself. As for inertia, one assumed it is determined by the mode in which matter moves through the flow of ether, as compared to a privileged mode of free moving.

Inertia and gravitation being phenomena not yet proven to have the same intimate fundamental nature, or to come out from a common root with electromagnetic phenomena, the need to test the coherence between *electromagnetism, inertia* and *gravitation* seems only natural. That trend of mind seems to ask for an **experimental investigation** of the now rather generally admitted validity of the Lorentz covariance hypothesis.

The principal motive of the acceptance in an extremely large extent of Einstein's relativist philosophy was motivated by the negative results of the Michelson-Moreley experiences, completed afterwards by the Kennedy-Thorndike ones, both performed with interferometers assembled *on rigidly aggregated-matter* supports.

Yet this very fact implies that all the so mentioned systems are particular by being of an overall electromagnetic nature. It is a fact that implies they are bound to be, all, Lorentz invariant.

In eagerness of generality, we will search for possible experimental devices that should run not *exclusively* based on electromagnetic couplings, but also on *by inertia and gravitation determined* ones.

An at-hand example of such a system is imaginable as a single arm electro-magnetic interferometer built with an end at a point A on the Earth, near the equator, and the other end on a geo-stationary satellite at B, preferably positioned on the vertical above A.

If so, what would be the experimental result delivered by a Kennedy-Thorndike interferometer (unequal arms, one of negligible length) built on such a physical base? More specifically**:** what would be the behavior over time of the interference spectrum of an interferometer consisting of a radio transmitter based on earth in A and a reflector or repeater on the above mentioned geo-stationary satellite in B, the phase difference between the waves departing and returning in A being monitored on 24 hours turns as well as on an annual variation?

In search for an answer, one may debate on two hypotheses –imagined as extremes**:**

a) the true laws of inertia and gravitation – together with Maxwell's equations – are all, in fact, closely or exactly *Lorentz-invariant*, the consequence being that the expected difference in phase would have to be nil – as consequence of the assumed general-invariance itself,

b) the inertia-gravitation laws are, *in fact,* exactly Newtonian – or in a different way *covariant* as the Fitzgerald-Lorentz asks.

2. Analysis

Supposing the second case is the real one and knowing that the experimental device so suggested would rotate with an angular-velocity $\theta = 2\pi / 86400$ rad/s**,** the phase-difference $\Delta\phi$ at recombination at A – the ambient ether being assumed in relative rest in the whole implied domain – results as follows**:** when the vector $\mathbf{A} - \mathbf{B}$, of length L, is collinear with **V – V** meaning the ether's velocity component into the plane in which $\mathbf{A} - \mathbf{B}$ rotates – the time-difference Δt upon recombination at A should be**:**

$$\Delta t_{\|} = L/(C+V) + L/(C-V) \equiv 2L\Big/C\left[1-(V/c)^2\right]$$

or, with λ for the wave-length of the emitted beam and $\beta = V/c$

$$\Delta\phi_{\|} = 4\pi(L/\lambda)(1-\beta^2)$$

c) when $\mathbf{A}-\mathbf{B}$ is orthogonal to $\mathbf{V}$**,** reasoning in the same way, one finds**:**

$$\Delta t_{\perp} = 2(L/c)\sqrt{1-\beta^2}$$

and, by consequence

$$\Delta\phi_{\perp} = 4\pi(L/c)\sqrt{1-\beta^2}$$

The phase shift at recombination, after a quarter turn of $\mathbf{A}-\mathbf{B}$, results as**:**

$$\delta(\Delta\phi) = \Delta\phi_{\|} - \Delta\phi_{\perp} = 2\pi\beta^2(L/\lambda)$$

and – because it is hard to imagine that β could be greater than $\mathbf{C}/1000$ – it becomes**:**

$$\delta(\Delta\phi) = 2\pi\beta^2(L/\lambda) \quad .$$

Assuming the difference of phase being monitored on the long run, one may await an evolution conforming to**:**

$$\delta(\Delta\phi) = 2\pi\beta^2(L/\lambda)\cos^2\omega t$$

the timing t being assumed to start when $\mathbf{A}-\mathbf{B}$ is collinear with $\mathbf{V}$.

It is obvious that a so configured system should show a very large phase shift – the product of L/λ, even when multiplied by β^2, looks gigantic compared to the interference patterns usually considered. That makes that one may wonder if such a powerful perturbation could have been assimilated – *without being identified as a specific one* – into the corrections of the GPS system. The problem, if so looked at, would consist in separating by Fourier analysis the as-above suspected kind of phase shift from the ensemble of the till-now well-known perturbing influences.

Following that trend of mind, one has to observe that our solar system moves with some 300 km/s in a 120° galactic longitude / +35° latitude (*cf.* E.P. Hubble, [2]), direction. A movement eventually determining, at the Earth's level, a into the ecliptic plane velocity-component roughly evaluated at**:**

$$300\sqrt{\sin^2 35^\circ + \cos^2 35^\circ \cos^2 60^\circ} = 211\,\text{km/s}$$

(an amateur's evalua tion!).

On the other hand the orbital movement of the Earth around the Sun would add a component of some 30000m/s in the equatorial plane. It is a component very strictly periodic, of half a solar day period and, of course, with an exactly annual recurrence.

Such influences, if real, should not be hard to identify as a specific component of a very precise twelve sidereal-hours periodicity in any Fourier analysis of the measured $\delta(\Delta\phi)$ data. If confirmed, one may hope to find some clues about a locally-defined absolute reference frame.

Knowing that the time required for a go-return of the signal between $\mathbf{A}$ and $\mathbf{B}$ is insignificant when compared to the 24 hours revolution-time of the Earth with its geostationary satellite, one may consider the possibility to read the interference spectrum after more than one go/return journeys of the waves between $\mathbf{A}$ and $\mathbf{B}$. In that case the shift into the phase-difference could be much larger and, by that, more easily separable from the other perturbing influences.

3. Applications

In [1], both phenomena of inertia and gravitation were supposed to stem from a same root, in fact, from the influence of the ambient ether flow on aggregate matter. On that line of thought and in the eventuality the above suggested type of Kennedy-Thorndike experience would have put in evidence an *absolute effect* – *i.e.* a non covariant Fitzgerald-Lorentz result on material, moving, systems – one may wonder if experiences aimed at evidencing a non-Lorentz covariance of inertia ***independently of gravitation*** could be imagined and run.

With that intent, we suggest a kind of Kennedy-Thorndike interferometer in which the *active* optic beam is bouncing between two reflective devices fixed on two heavy masses rigidly bound together by a thin thread-like element, the orthogonal reference arm being reduced to a negligible length. The so configured ensemble is imagined rotating independently somewhere in free space – meaning by that**:** gravitating freely under the sole influence of inertia and the centrifugal forces acting on it.

In a so configured and conditioned interferometer the arm's length is determined *exclusively* by**:**

1) the at-rest length, L_o of the bounding wire system,

2) the momentary Fitzgerald-Lorentz contraction

3) the Hook strains generated by

4) the constant intensity of the centrifugal force together with the *periodically-variable inertial force due to the movement induced,* ***as a perturbation,*** *by the Fitzgerald-Lorentz contraction*.

More explicitly**:** the interferometer's arm being of a compact material nature, its length – under the assumption of the ether hypothesis – would be submitted to a *factual* Fitzgerald-Lorentz contraction engendering a perturbing displacement on the otherwise perfectly circular – *i.e.* Newtonian – trajectory of radius R_o of the two rotating equal masses (Fig. 1).

Imagining an as above suggested device installed in space and made to rotate with an angular velocity *small enough* to permit the arm's extremities to follow **at its whole value** the Fitzgerald-Lorentz contraction, no displacement of the interference spectrum is expected, the experiment remaining a classical Kennedy-Thorndike one.

Yet, if the rotational speed is big enough to hinder – *due to a by* ***inertia*** *induced delay* – part of the Fitzgerald-Lorentz contraction, a time-dependent variance of the interference spectrum should become observable.

If eventually found as really existing, and if time-monitored, the phenomenon could help understanding if, and how much, *inertia differs in nature from the electromagnetic phenomena*.

Trying to determine how a so in theory structured device could be factually built, it seems rational to assume all the interferometer's facilities and functional gear to be concentrated, in equal masses, at the ends of the rotating arm. If so, the trajectories – *imagined in an "**a priori**" way* – of the reflecting devices at the interferometer's extremities together with the determinant parameters of the system are sketched in Fig. 1.

Specifically:

a) the Newtonian trajectory, assumed to be a circle of radius R_o determined by the static thread's length L_0 supplemented with the by the centrifugal forces determined elongation, shown in Fig. 1 as the top line;
b) the trajectory determined by the Fitzgerald-Lorentz contraction at small rotational speeds; the middle line
c) the same as in case **b** but correspondent to a high rotational speed; the bottom line.

By its design the ensemble should be able to read the expected difference in lengths, ΔL, of the two optic paths in their dependence of the device's angular coordinate $\theta(t)$ – here assumed as the complement of the angle determined by the interferometer's rotating arm and the ether's velocity-component in the device's rotating plane, (Fig. 1).

With the symbolism adopted in Fig. 1, one finds:

$$\delta(\Delta L) = 2(\Gamma - \gamma)$$

Γ meaning the distance between the Fitzgerald-Lorentz 'at ease' contracted trajectory referred to the Newtonian one, while _ symbolizes the similar distance at high rotational speed (Fig. 1), both obviously time dependent.

The expected value $\delta(\Delta L)$ so defined can be calculated by means of a sequential program of finite-difference applied to the fundamental laws of dynamics:

$$(d\gamma / dt)_i = (d\gamma / dt)_{i-1} + (d^2\gamma / d^2t)_{i-1}\Delta t$$

or, explicitly,

$$(d\gamma / dt)_i = (d\gamma / dt)_{i-1} + (F_i / m)\Delta t \quad , \quad \gamma_i = \gamma_{i-1} + (d\gamma / dt)_{i-1}$$

the index i indicating the indexed variable calculated at step i.

In the above relations F_i represents Hooke's elastic forces values generated by the Fitzgerald-Lorentz contraction when the system *runs dynamically* – meaning by this: running in a not cinematically-steady state.

As for the Hook component due to the steady influence of the centrifugal force it is supposed included in the value of R_o. The constant parameter m means the mass' value of one of the equally ponderous bodies attached at the ends of the linking-system, assumed to be reduced, in theory, to a single wire of sectional area S.

With that symbolism Hooke's force $\mathbf{F}$ may be formulated as:

$$F_i = S\sigma \equiv SE(\Gamma_i - \gamma_i) / R_o$$

σ meaning the specific stress under the as above assumed dynamic strains and E the value of the modulus of elasticity proper to the wire's material.

Under the influence of the Fitzgerald-Lorentz contractions, as above assumed, Γ takes the form

$$\Gamma_i = R_0 - R_0\sqrt{1-(V/c)^2 \sin^2\theta_i}$$

which, for values of $V/c \ll 1$, may be approximated as

$$\Gamma_i = \tfrac{1}{2} R_0 (V/c)^2 \sin^2\theta_i$$

θ_i meaning – as shown in Fig. 1 – the complement of the angle between the interferometer's arm and the velocity component – into the rotation plane of the apparatus –of the local ether relative to the apparatus.

Assuming – *presently on basis of bare intuition* – that the interval $\Gamma - \gamma$ grows when the rotational speed of the ensemble is increased, the interest of making that parameter as big as possible becomes evident. As a matter of fact the value of the angular speed, symbolized by ω, is, practically, limited by the condition the stress in the wire should not exceed its elastic admissible value, *i.e.* σ_a.

So, the maximum admissible value of _ results from the condition: $mR_0\omega^2 = S\sigma_a$ or, equivalently, $\omega = \sqrt{S\sigma_a / mR_0}$.

Choosing – in intent of illustration – a set of parametric values as: $R_o = =$ 3000 m, $m = 1000$kg.; $S = 10^{-6}$ m^2; $\sigma_a = 2.1\times 10^8$N/m^2; $E = 2.1\times 10^{11}$N/m^2, the value $\omega = 8.367\times 10^{-3}$rad./s results.

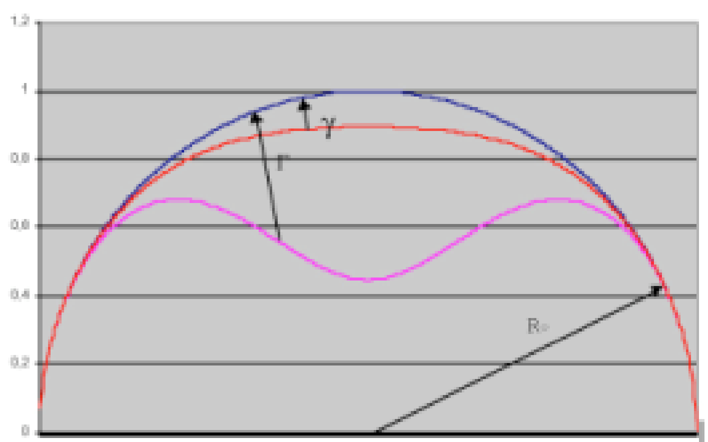


Fig.1 Geometry of the theoretically assumed trajectories (grossly exaggerated). Horizontal axis 0 to π rad.

Abscissas: values of θ (in 0.35° steps), meaning the complement of the angle between the interferometer's arm and vector $\mathbf{V}$, the component into the plane of rotation of the ether velocity.

Ordinates: Lengths of the interferometer's arm, the Newtonian one being considered unity.

Meaning of the series plotted: **top** – Newtonian determined; **middle** – Fitzgerald-Lorentz determined at small rotation speed; **bottom** – the same as before at high rotational speed.

Imagining that the relative speed of the apparatus relative to the ambient ether could be of the same order as the one of the solar system with respect to the average cinematic state of the whole cosmos –evaluated at 300 km/s – and imagining the device rotating in a plane containing the vector representing that speed, the above written sequential system becomes:

$$(d\gamma / dt)_i = (d\gamma / dt)_{i-1} + 0.7 \cdot 10^{-2}(1.5 \times 10^{-3} \sin^2 \theta_{i-1} - \gamma_{i-1})\Delta t;$$
$$\gamma_i = \gamma_{i-1} + (d\gamma / dt)_{i-1}\Delta t$$

The analytical system as above determined was processed by means of an Excel program. A set of well-defined functions are attributed to columns A to L, as shown hereafter. Bold capitals stand for sequential functions representing the variables, the parametric values as well as the by computer obtained figures being expressed in the MKS system.

A) **A**(i) = **A**(i), with **A**(i)= Δt, Δt meaning an *arbitrarily* chosen sequential time-step,

B) **B**(i) = **B**(i), with **B**(1) = S, S meaning the wire's cross-section area

C) **C**(i) = **C**(i-1), with $\mathbf{C}_1$ = R_0, R_0 meaning the Newtonian trajectory's radius

D) **D** = **D**(i-1), with $\mathbf{D}_1$= m, m meaning the value of one of the rotating masses

E) **E**(i) = **E**(i-1), with $E(1) = \sqrt{B_1\sigma_{el}/C(1) \cdot D(1)}$, *i.e.* the maximum admissible rotation speed

F) **F**(i) = **F**(i-1), with **F**(1) = $(V / c)^2$, meaning the numerical value of $(V / c)^2$

G) **G**(i) = **G**(i-1) + **A**(i) meaning the running time-step

H) **H**(i) = **E**(i) * **G**(i) meaning the angular coordinate θ ("*" is the multiplication-symbol)

I) **I**(i) = (**C**(i)/2) * **F**(i)*sin2**H**(i) the 'at ease' Fitzgerald-Lorentz Γ value

J) **J**(i) = **J**(i-1)+**B**(i-1) * 2.1 * 10^{11}*{**I**(i-1)-**K**(i-1)***A**(i-1)}/{**D**(i-1)***C**(-1)} meaning $d\gamma / dt$.

K) **K**(i) = **K**(i-1) + **J**(i) * **A**(i) meaning the dynamic γ displacement

L) **L**(i) = **I**(i) – **K**(i) meaning $\Gamma - \gamma$.

The Figures resulting from the so configured program – with $\Delta t = 2$ seconds as time-step, are charted in Fig. 2.

The chart clearly shows that the Fitzgerald-Lorentz *perturbed* trajectory is less simple than the one sketched in Fig. 1. It seems that the real trajectory enfolds the "at ease" one – *i.e.* the one *corresponding to a very low rotational speed of the system* – meandering around it.

It certainly is a surprising revelation. At first sight one may suspect it could be a parasitic computational oscillation introduced by calculus with finite differences. That hypothesis may be ruled out comparing the Figures coming out from the $\Delta t = 2$ s/step program with the ones obtained with a more refined computational evaluation, *i.e.* one with $\Delta t = 0.5$ s/step. Commuting the program from $\Delta t = 2$ s. to $\Delta t = 0.5$ s did not significantly modify the computed Figures.

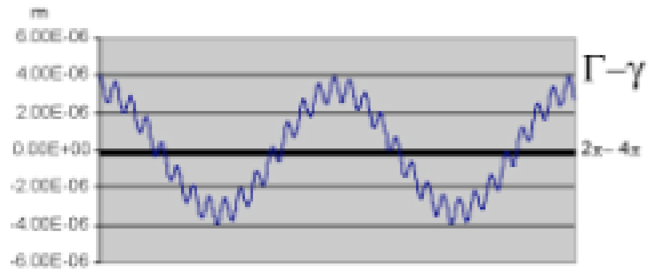


Figure 2. Optic-path-length variance along a 2π rotation of the interferometer.

The abscissa interval was extended on 2π - 4π rad in view to minimize the possibly erratic influence of the initial values at the calculus' starting point.

The phenomenon, when more carefully looked at, could be interpreted as a mechanical self-oscillation *started and maintained by the periodic Fitzgerald-Lorentz contraction*.

Resorting to a by classic mechanics evaluation the system *proper-oscillations* constant, ω_p should show the value:

$$\omega_p = \sqrt{\frac{ES}{mR_0}} = \sqrt{\frac{2,1 \times 10^{11} \times 10^{-6}}{1000 \times 3000}} = 0.2646 \text{ rad / s}$$

Compared to the device's rotational speed, it appears to be 29.44 times greater. Yet, relative to the Fitzgerald-Lorentz's contraction rhythm, it should be only 29.44 **/** 2 = **14.72** times greater. Actually, by counting the undulations shown in Fig. 2 one finds that there are 30 oscillations for one rotation of the apparatus.

The above-mentioned observation leads to the conclusion that the most probable explanation is that one should think at a high-order mode of *harmonic hang-up*, somehow phase-displaced relative to the Fitzgerald-Lorentz variable constraint – a displacement easily readable in Fig. 3.

Equally surprising may appear the indication from chart nr.3 that the difference $\Gamma - \gamma$ becomes negative in a limited domain in the vicinity of the maximum value of the Fitzgerald-Lorentz contraction, *i.e.* near = $\pi / 2$ **;** $3\pi / 2$, *etc.* The phenomenon is still intuitively understandable by simply observing that a fast Fitzgerald-Lorentz contractionon may determine a perturbing acceleration strong enough to transgress the dynamic steady-state position.

If the phenomenon would factually evolve as above suggested, one may interpret it as the superposition of two oscillations**:** one of large deviations with a maximum variation of 7,82 10^{-6}m and a low pulsation-rate of 8.367$\times 10^{-3}$ rad/s (Fig. 2), associated with a second one of a much smaller amplitude, *i.e.* 1,51 10^{-6} m., but with a significantly higher pulsation-rate, in essence of 0.2646 rad/s. (Figs. 2 and 4). If so, of first importance would be the higher frequency component, theoretically anomalous but just by that easily separable from the other manifestations induced by mechanical influences acting on the interferometer.

The so computed Figures as well as the trace in Fig. 2 show that the maximum phase difference of the interfering beams should be of the order of:

$$\Delta\varphi = 2\pi\Delta L / \lambda = 4\pi(\Gamma - \gamma) / \lambda = 0.503 \times 10^{-4} / \lambda$$

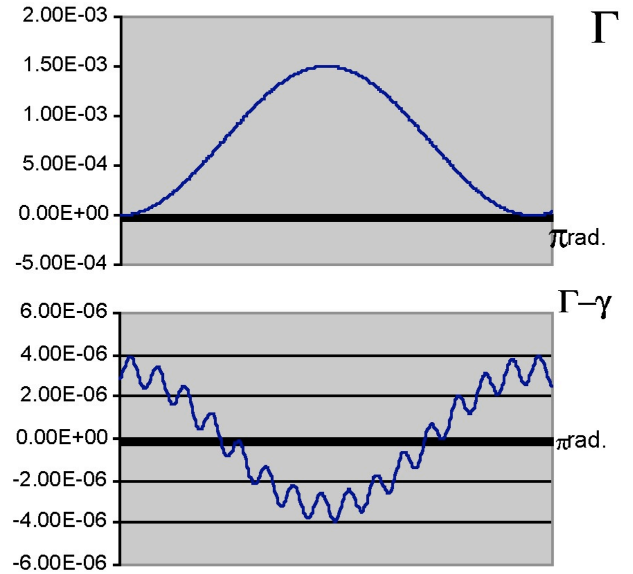


Figure 3. Fitzgerald-Lorentz contraction compared with the inertial displacement.

Knowing that λ in a laser beam is of the order of 10^{-6}m, one may hope the interference-specter's displacement during a rotation of the theoretically imagined experimental device would be in the range of the existing experimental facilities. As for the phase difference due to the higher-frequency component, even if its amplitude would be much smaller than the fundamental one, its higher frequency suggests it could be more easily detectable by filtered or resonant amplification.

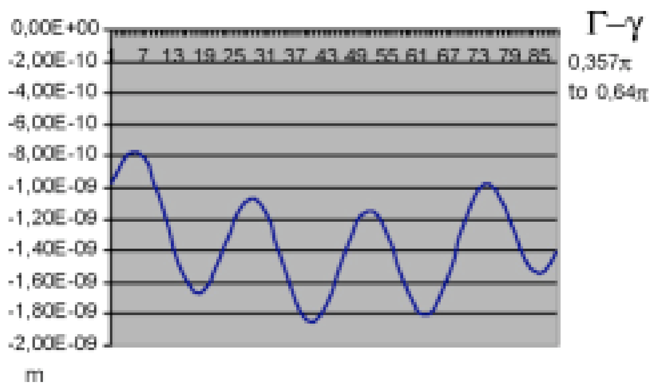
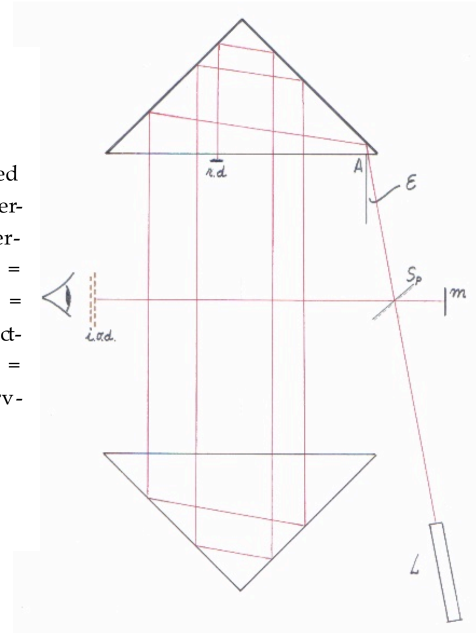


Figure 4. Detail of the high frequency component.

The aim of the above presented analytical example was only to sketch the structure and working principle of an experimental device eventually capable to investigate, from a relativist point of view, the inertia phenomenon. The device as above described represents the simplest *in principia* form in intent of theoretical evaluations. For practical purpose, much more refined solutions and contraptions are to be imagined in view to put in practice a really useful experiment.

As a simple hint – perhaps a wishful thinking illusion – aimed at designing and running a somehow more practical device than the 'long-thread' one, only of interest for a theoretical evaluation, one may consider an apparatus of the kind sketched in Fig. 5.

Figure 5. Suggested small scale interferometer. L = laser-beam generator, S_p = beam splitter, m = mirror, Rd = reflecting device, iod = interference observing device.



A well-collimated laser beam, generated at L, is supposed injected through zone A – under an as small as practically possible ε angle – into a two-prism multiply reflective device. By adequate designing and alignment of the ensemble, the multi-looped beam should be made to return, after an orthogonal reflection at Rd, on the same way as the incoming one and emerge in A.

By means of a splitting device S_p and the mirror m the two beams should be guided to interfere, coherently, in the observing iod facility. Assuming, hypothetically, that well collimated laser beams of more than some 3000m total length and some 1/10 mm width are now in the state of the art possibilities, and also homogeneous glass prisms of some 20 to30 cm hypotenuses, strictly shaped and monochromatically anti-reflex coated, the overall dimensions of the apparatus may be imagined reducible to some 10m total length, yet still able to reach the same sensitivity as the 'long thread' one, above evaluated.

One may imagine a so shaped device installed in interplanetary space and run under different azimuths. If successful, such an experiment may be considered as an irrefutable proof of the ***non-generality*** of the special theory of relativity – the in the experience implied accelerations being much too small to exile the phenomenon from the Restricted Relativity philosophy.

When lagging in a fairy-tale mood the author wonders if some NASA specialist will not, by chance, stumble on the problem and offer a well-founded answer. Lacking the power to experiment, the author dares only wander.

Acknowledgment

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References

[1] Dan Romalo, "On Albert Einstein and his Relativities", Proceedings of the NPA **3** (2) 233-245 (2006). One should take into account that all the references mentioned in [1] are, implicitly, essentially-important in the here forwarded argumentations.

[2] E.P. Hubble, *cf.* file: //C:\Program%20Files\Britanica\BCD\Cache_21_ArticleRil.htm.