The Inertia in a Revised Mach's Principle

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Abstract

Using the Bridge Theory, in which the electromagnetic interactions between pairs of charged particles create dipolar electromagnetic sources able of emulate the characteristic Quantum-Relativistic behaviour which characterises the matter-wave duality of particles, inertia is proved to be an emergent property originated by the quantised exchange of energy and momentum between a charged particle and the surrounding vacuum, a sort of Dirac's ether with which each charge interacts acquiring rest mass from the Higgs field and manifesting an inertia which is growing with the energy in agreement with the Special Relativity. In this context space-time characterising the vacuum is a Galilean absolute inertial frame of reference, inside which all particles move and interacts in a new version of the Mach principle. The physical conditions to reduce the inertia of material bodies in motion in the vacuum are suggested.

Keywords

Electrodynamics, Inertia, Mass, Absolute Reference Frame, Space-time, Ether, Special Relativity, Quantum Mechanics, Bridge Theory, Mechanics.

I. INTRODUCTION

Historically, the inertia is a resistant balanced force produced by a body when its state of motion is changing, i.e. when it is accelerated the application of a force proportional to the final acceleration is required. The constant of proportionality between force and acceleration is the measure of the inertia and is equal to the ratio between the applied force which is the cause that produces the motion variation and the effect on the body, i.e. its acceleration. Following the Mach's conjecture, the mass, i.e. the inertia, is originated by the continuous and chaotic interaction of the body with all the matter that fills the universe. On the other hand, Mach's idea revisits an older idea of George Berkeley who considers the fixed stars as responsible for the production of the inertia of matter. In both cases the inertia would be produced by the interaction of a material body with an unknown mysterious force field. Considering only the long range known forces in the actual universe, for the large distances involved among galaxies or galaxies clusters, only the electromagnetic forces can be candidate to produce the inertia of the bodies. In fact, gravity how we know it usually, can have on identical bodies equal effects only at large scale, because the variability of the local distributions of matter can produce on identical bodies much different inertial effects.

An interesting approach to Mach's idea was been proposed in the past by Sciama [1] and with some variation by Davidson [2]. In both approaches, relatively to the contemporary knowledge, the inertia spring out as an effect of a force produced by two coupled fields: the gravoelectric and gravomagnetic fields of the whole universe. These approaches agree with the General Relativity and consider the universe as a continue field able to neutralise the gravitational action of the local matter, so that each body in the own frame of reference is free from gravitational effects. In this case the inertia spring out when the gravomagnetic field with intensity proportional to the rotation of the universe around the own centre of mass involves accelerated matter. This approach although gives a possible explanation to the inertia, requires a steady state universe model, able to maintain with its uniform rotation an inertial effects unchanged in time on all matter in each its part when matter is moving.

A more recent approach was given by Haisch, Rueda and Puthoff [3] and later by Vigier [4], in both cases inertia is described not as a contribution due to the whole universe, but as a local phenomenon produced from the interaction of each particle without inertia with the virtual particles of a pseudo-vacuum, a conceptual and theoretical evolution of the Dirac's ether [5], successively revised by Bohm and Vigier [6 - 9], de Broglie [10], Sudarshan et Al. [11,12] and not least in time by Petroni and Vigier [13].

A recent further theoretical progress on this topic is due to Rueda and Haisch [14] which they have proposed of replace the Mach's principle with a type of local electromagnetic interaction, consistent with the principle of causality, not necessarily requiring the existence of the Higgs's boson recently discovered, to produce the inertial mass of particles. Considering the similarities among the Haisch-Rueda-Puthoff-Vigier (HRPV) theories and the phenomenology on which is build the Bridge Theory (BT) [15] used to describe matter, light and their quantum-relativistic interactions in an unique compatible theory, a new model of inertia involving only the charged particles is proposed. The BT is completely developed starting from a non-ideal dipole model, used for the proofs [16] and [17] of the conjecture [18] concerning the physical role of the its transversal component of the Poynting's vector to localize inside the first electromagnetic wave front an amount of energy and momentum in agree with ones of a photon. Herein, the role of the Higgs boson is assigned to a Dipole Electro-Magnetic Source (DEMS) with spin zero, produced in the direct interaction between a virtual charge particles polarised starting from an electromagnetic pseudo-vacuum (an electromagnetic version of the Dirac's ether) and an elementary particle of the Standard Model, neutrino excluded. The interactions occur as described in the recent quantum-relativistic developments of the BT [19], now able to describe both the electromagnetic nature of the pilot wave emitted by the dipole source, as the de Broglie-Bohm theory requires and the quantum-relativistic local behaviour of the particle, that interacting with the vacuum acquires a value of inertia that at low energy agrees with the Newtonian one.

II. THE MACH'S PRINCIPLE IN BRIDGE THEORY

The Bridge Theory is based on the fundamental principle that each charge, despite it is massless, owns a specific energy of rest, which is originated by its direct interactions with all the virtual anti-charges created in polarised pairs by an electromagnetic vacuum with which can to be causally in contact. Each interaction produces a dipole which is a Dipole Electro-Magnetic Source (DEMS) [15], localising inside the own first wave front all the characteristic energy and momentum of a photon exchanged during the interaction, formally described in the usual quantum form $E = h\nu$ where also the theoretical evaluation of the Planck constant is obtained [15,17].

The vacuum can be considered a Dirac's ether where each interaction occurring between the virtual pairs have the effect to produce a DEMS in which a photon is exchanged and the metric of the local space-time is defined by the propagation of the electromagnetic wave of the source. In this sense, the vacuum, Dirac's ether and space-time are physically equivalent. In fact, space-time is produced by a stochastic distribution of DEMS originated by an infinite number of virtual pairs created inside the electromagnetic field of an original primitive DEMS. Since a charge at rest suffers the exchange of energy and momentum throughout its interactions with all the vacuum, each particle acquires a chaotic vibrating motion characterising its rest energy. The inertia is therefore produced by the interactions of the particle with all the vacuum of the universe.

Following the previous idea, we assume that only pairs of quarks $(u,\bar{u}),(d,\bar{d})$ and of lepton (e^-,e^+), i.e. only stable charged fermions created in pairs can to be subject to inertial effects. In this case the mass, i.e. the measure of the inertia of the particles, is originates from their interactions with all space-time, i.e. with the vacuum field. The interactions of the particles in describing their inertia has therefore a role equivalent to that described in the Higgs model to produces the mass of a particle at rest. Other particles as the intermediate bosons $W^{\pm}$ being subject to spontaneous decays, cannot be considered elementary particles because are not stable particles and probably acquires mass by means of the elementary particles from which they are formed.

In this work, the direct interaction between a particle and the whole universe, i.e. the multi-interaction of each particle with the polarised vacuum and with all the other real antiparticles with which can be in causal contact producing an exchange of virtual photons, it is equivalent to an electromagnetic Mach's principle.

The particles belonging respectively to the second and third generations of the Standard Model cannot at the moment to be considered because used to build not stable particle in this universe.

III. WAVE DESCRIPTION OF A PARTICLE

In agreement with the extended BT [19] it is possible to describe the energy of the photon exchanged in the direction $\hat{\boldsymbol{k}}$ which is jointing a particle moving along a direction $\hat{\mathbf{r}}$ with velocity β, with the particle with the role of observer (in general an anti-charged particle) using the generalised Compton's wavelength

$$\lambda_0 = \lambda_c \gamma \left(1 - \boldsymbol{\beta} \cdot \hat{\mathbf{k}}\right) \tag{1}$$

where

$$\lambda_c = \frac{2hc}{\varepsilon} \tag{2}$$

is the Compton wavelength of a DEMS associated to a pair of interacting particles with rest energy ε in relative motion. In fact, using the Eq. (1) and (2), the energy of the photon exchanged between the centre of mass of the DEMS and the observer is given by

$$E_\Gamma = \frac{hc}{\lambda_0} = \frac{\varepsilon}{2} \frac{\sqrt{1-\beta^2}}{1 - \boldsymbol{\beta} \cdot \hat{\mathbf{k}}} \tag{3}$$

(see fig. 1) where in agreement with [19] the total energy of the incoming particle is $E = \varepsilon\gamma/2$.

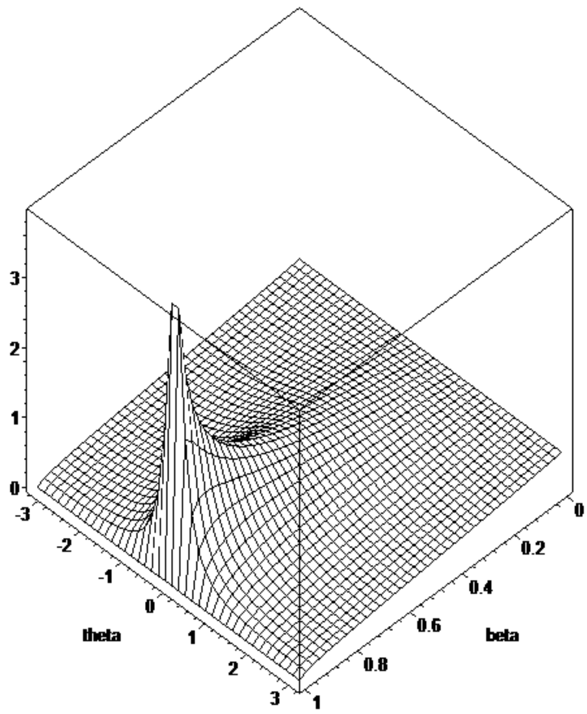

Fig. 1: The generalised Compton emission (3) per unit of rest energy E_Γ/ε**.**

The energy (3) has got two physical constraints: the velocity of the particle cannot exceed the light speed, the angle θ of interaction and observation between the sight line of the observer and the velocity of the particle along its trajectory is within the interval $0<\theta\le\pi$, so when the particle moves at low speed $\beta<<1$, the frequency of the DEMS signal converges to the Compton's value

$$\nu_c=\frac{\varepsilon}{2h} \tag{4}$$

of a particle with a rest energy $\varepsilon/2$, i.e. Eq. (4) is coinciding with the Compton frequency associated to an impinging non-relativistic particle, on the otherwise, when a head to head interaction occurs at an extreme high speed $\beta\cong 1$, the angle of interaction – observation is closer to zero and in this case the Eq. (3) gives a frequency converging to de Broglie's one:

$$\nu_{db}=\frac{\gamma\varepsilon}{h} \tag{5}$$

of a particle with total energy $\gamma\varepsilon$, proving that the equation (3) is able to describe the electromagnetic energy of the photon exchanged between particle and observer in each dynamic condition.

IV. DIRECTIONAL INERTIA AND NEWTON'S DYNAMICAL PRINCIPLES

In agreement with the second Newton's law, the inertial mass of an impinging particle can be estimated considering the variation of its momentum with respect the variation of its speed. Assuming in agreement with BT the momentum $P=\gamma\beta\varepsilon/c$ exchanged between an impinging particle and its observer to be the total available electromagnetic amount of momentum of the DEMS produced, using (3), the electromagnetic momentum emitted towards the observer is given by $P_\Gamma=E_\Gamma/c$, which can be used to define the directional inertia shown by the particle along the sight line of an observer:

$$\mu=\frac{dP_\Gamma}{dv}=\frac{\varepsilon}{2c^2}\frac{\hat{\boldsymbol{\beta}}\cdot\hat{\mathbf{k}}-\beta}{\sqrt{1-\beta^2}\left(1-\hat{\boldsymbol{\beta}}\cdot\mathbf{k}\right)^2} \tag{6}$$

In Fig. 2-a and Fig. 2-b is shown as the directional inertia (6) becomes zero when the interaction angle $\theta=\cos^{-1}\beta$ and negative when $\cos\theta<\beta$, whereas for the standard relativistic case $\theta\cong 0$, $\beta\cong 1$, is possible to evaluate the longitudinal inertia of the particle accelerated during the interaction by the point of view of a target observer placed alongside the trajectory:

$$\mu_{//} = \frac{\mathbf{F}_{//}}{\mathbf{a}_{//}} = \frac{\varepsilon\gamma^3}{2c^2}(1+\beta) \cong \frac{\varepsilon\gamma^3}{c^2} \tag{7}$$

Continuing to use the directional inertia (6) and Eq. (3), we can define the total transversal inertia of the particle as one associated to the interactions occurred between the incoming particle and the observer along all the sight lines of the observer within the angular interval $0<\theta<\Theta$, where Θ is an useful variable defining an upper angular limit:

$$\mu_{\Theta} = \int_0^{\Theta} \mu d\theta = \frac{d}{dv}\int_0^{\Theta} P_{\Gamma} d\theta = \frac{dp_{\Theta}}{dv} \tag{8}$$

where

$$\begin{aligned} p_{\Theta} &= \int_0^{\Theta} P_{\Gamma} d\theta \\ &= \frac{\varepsilon}{2c}\sqrt{1-\beta^2}\int_0^{\Theta}\frac{d\theta}{1-\beta\cos\theta} \\ &= \frac{\varepsilon}{c}\tan^{-1}\left(\sqrt{\frac{1+\beta}{1-\beta}}\tan\frac{\Theta}{2}\right) \end{aligned} \tag{9}$$

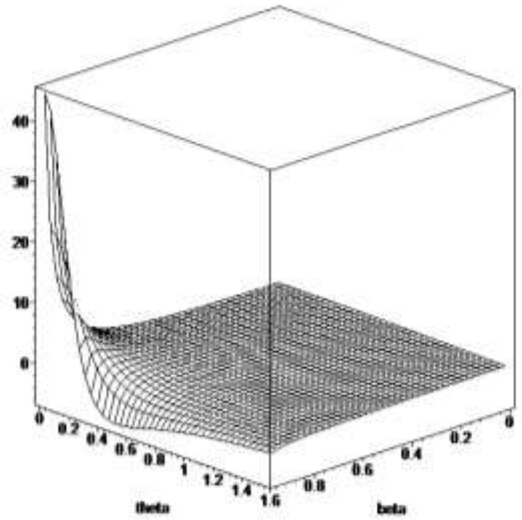

Fig 2-a. Behaviour of the directional inertia (6) in the normalised form $\mu c^2/\varepsilon$, viewed A side.

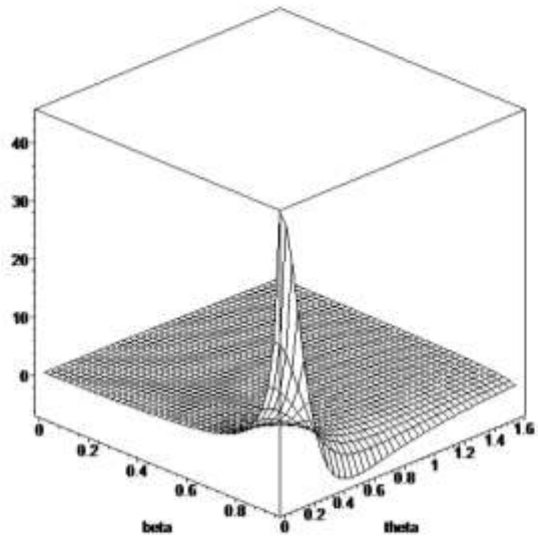

Fig 2-b: Behaviour of the directional inertia (6) in the normalised form $\mu c^2/\varepsilon$, viewed B side.

is assumed the mechanical momentum exchanged with the observer in the angular interval $0<\theta<\Theta$, so that using the last equality of the Eq. (8) and Eq. (9), the resulting transversal inertia in that defined angular interval is given by

$$\mu_\Theta = \frac{\varepsilon\gamma}{c^2}\frac{\tan\frac{\Theta}{2}}{1-\beta+(1+\beta)\tan^2\frac{\Theta}{2}} \tag{10}$$

Extending Eq. (10) to the total inertia felt by the observer during all the Alpha (A) phase of the DEMS corresponding to the approach phase between the two particles, where the angular interval has upper limit $\Theta = \pi/2$, Eq. (10) gives in agreement with the relativistic definition of transversal mass

$$\mu_\perp = \frac{\varepsilon\gamma}{2c^2} \tag{11}$$

that proves the equivalence between the relativistic and inertial mass of a particle.

If we consider the total process of observation starting from A phase and ending with the destroying of the DEMS at the end of the Omega (Ω) phase, the angular interval of the total transversal mass (8) has upper limit $\Theta = \pi$ and correspond to the overlap of the two distinct DEMS phases A and Ω. In this case Eq. (10) yields a null total inertia:

$$\mu_\perp + \bar{\mu}_\perp = \lim_{\Theta\to\pi}\mu_\Theta = 0 \tag{12}$$

Using Eq. (12) but also using Eq. (8), it is easy to prove that in the Ω phase the inertia of the particle is equal but changed in sign to the inertia of the A phase, i.e. the transversal mass in the Omega phase of the DEMS is negative

$$\bar{\mu}_\perp = -\mu_\perp \tag{13}$$

implying using Eq. (8) and (12)

$$\left.\frac{dp}{dv}\right|_0^\pi = 0 \tag{14}$$

This result in terms of exchanged momentum means that the observer gives back to the interacting particle the same amount of momentum received during the A phase. This conclusion has two non banal implications. In fact at the end of the Ω Phase of the DEMS or without DEMS formation:

(a) *particles does not manifest inertia, i.e. they have not mass;*

(b) *their momentum return to be those that were before the DEMS formation remaining unchanged.*

A. *The first Newton's law*

The statements above have both to do with mechanical reality of the world. Reality is all what is perceptible using human senses or technical instruments, so without the production of the DEMS, the mass does not exist. In particular the second statement has to do directly with the first Newton's principle:

(I) *When a particle moves in the lab, the observation of the particle realized without exerting external forces, do not modify its original momentum.*

B. *The Second Newton's Law*

Equation (8), (10) and (11) allow to define a transversal force acting on the observer during the realisation of the A phase of the DEMS, the force experienced by the observer is in agreement with a relativistic transversal force occurring in all directions excluding the longitudinal one

$$\mathbf{F}_\perp = \frac{\varepsilon\gamma}{2c^2}\frac{dv}{dt}\hat{\mathbf{t}} \tag{15}$$

Since Eq. (15) is obtained using the integral definition (9) that excludes the direct interaction of a moving particle along the initial direction of motion $\theta = 0$, considering the longitudinal force (7) and the transversal one (15), we can write a complete relativistic description of the second Newton's principle with the overlap of the two vectors component of the strength acting on the observer during the production of a DEMS:

$$\mathbf{F} = \left(\mu_{//}\frac{dv}{dt}\hat{\mathbf{l}} + m_\perp\frac{dv}{dt}\hat{\mathrm{t}}\right) = \mathbf{F}_{//} + \mathbf{F}_\perp \qquad 16)$$

In this situation longitudinal and transversal forces do not act simultaneously on the observer but in time during the interaction. In fact the initial longitudinal repulsive force produced at zero angle has effect only when particle and observer interact head to head, than the force becomes transversal as when the A phase begins for a particle moving on a trajectory alongside the observer. In general during the interaction the force between particle and observer is acting along a variable angular direction inside the interval $0 < \theta < \pi/2$, each angular direction has a different weight but the resultant interaction correspond to the effective angle

$$\bar{\theta} = \tan^{-1}\frac{F_\perp}{F_{//}} = \tan^{-1}(1-\beta) \tag{17}$$

which value is within the interval $0 < \theta < \pi/2$, therefore when two particles interact directly at low energy $\beta \cong 0$, considering their space-time evolution, the interaction occurs with an effective mean angle $\bar{\theta} = \pi/4$. This same result was obtained in ref. [17] starting from symmetry considerations on the free interaction of a couple of charged particles. The angular value obtained has allowed to calculate theoretically and consistently with the DEMS model, the exact value of the fine structure constant associated with the formation of the dipole and consequently the value of Planck's constant. The success of the primitive quantum electromagnetic dipole model [17] (see also [16, 18]) has allowed to develop the Bridge Theory [15] in the form [19], both here used.

C. *The third Newton's law*

Considering the forces acting during all the DEMS process formation, using Eq. (8) in agreement with second Newton's law, the repulsive force acting during the A phase between the impinging particle #1 on the observer #2 is

$$\frac{dp_{1,2}}{dt} = \mu_{\perp} a = \frac{\varepsilon\gamma}{2c^2} a \tag{18}$$

whereas the attractive force acting during the Ω phase is

$$\frac{dp_{2,1}}{dt} = -\mu_{\perp} a = -\frac{\varepsilon\gamma}{2c^2} a \tag{19}$$

whose sum, as previewed by the third Newton's law is null

$$\frac{dp_{1,2}}{dt} + \frac{dp_{2,1}}{dt} = 0 \tag{20}$$

V. THE GALILEO AND MACH'S PRINCIPLE IN BRIDGE THEORY

When a body moves with constant speed or it is at rest, are there observable differences? In other words, can an observer to experience differences between when it is in motion at constant speed or it is at rest? Considering a charged particle, if it is alone in the universe cannot interact exchanging energy and momentum with anything, hence no measure of momentum or mass can be realised. In this case the problem can be turned in the following terms, without external interactions, does a particle can have mass and momentum? Following the Galileo's principle, a body or particle without external influences continue to move with the same velocity and momentum, but what value of momentum can it have if it is does not never been observed? Following the Mach's principle, in a classical empty space a body cannot have inertia, hence a particle moves with constant velocity without mass and momentum and for an observer placed on the body it is impossible to know if it is at rest or in motion. Considering the Mach's principle applied to the BT, an elementary charged particle exists only if it is created in pairs from vacuum. If a charged elementary particle is in motion in vacuum with a constant speed, an other companion particle with opposite charge in causal contact with it must exist. Independently by their reciprocal distance and relative speed, each electric field line is connecting the two particles, emerging or entering locally in the point-like charges everywhere radially in all the solid angle. For the spherical symmetry of the particles imbedded in a vacuum, without external observers moreover to their self, Eq. (3) suggests to set the interaction angle between particle and antiparticle to $\theta = 0$ for each radial direction in space. Each connexion occur throughout virtual dipoles exchanging momentum between particle and vacuum. Considering the whole solid angle, the total momentum exchanged along the electric field lines with the companion charge, occurs throughout a virtual charges polarised in the vacuum as if the charge of the companion particle were uniformly distributed on a sphere of infinite radius over the entire solid angle giving a total momentum:

$$\begin{aligned} P^{+} &= \frac{\varepsilon}{8\pi c}\sqrt{\frac{1+\beta}{1-\beta}}\int_0^{2\pi} d\varphi \int_0^{\pi} \sin\theta \, d\theta \\ &= \frac{\varepsilon}{2c}\sqrt{\frac{1+\beta}{1-\beta}} \end{aligned} \tag{21}$$

where defining the Doppler frequency for a particle at rest

$$\nu^{+} = \frac{P^{+}c}{h} = \frac{\varepsilon}{2h} \tag{22}$$

its value can never be null because the momentum (21) is depending from the energy $\varepsilon \neq 0$. Using the Eq. (21) with $\beta = 0$ and the Eq. (22), the lower limit of frequency defines the rest energy $E_0 = h\nu_0^{+} = \frac{\varepsilon}{2}$ of the particle when it is stationary respect the vacuum, in the model this energy is assumed to be equivalent to the mass energy acquired by an elementary charged particle of the Standard Model when it interacts with the vacuum. Following this idea the electromagnetic mass of an elementary charge particle using (22) is defined

$$m = \frac{E_0}{c^2} = \frac{\varepsilon}{2c^2}\ , \tag{23}$$

using which the Eq. (21) becomes

$$P^{+} = mc\sqrt{\frac{1+\beta}{1-\beta}} \tag{24}$$

Equation (24) confirms the presence of a zitterbewegung of the particle at a characteristic frequency $\nu_0^{*} = mc^2/h$ originated by a chaotic exchange of momenta with the vacuum field. The effect is similar to a Brownian motion which makes tremble the particle. Using the equation (24), its development at the first order in series of Mc Laurin

$$P^{+} = mc + mv + ... \tag{25}$$

gives an estimation of the momentum of the particle in the Galileo's principle, without it interacts with external observers, i.e. Eq. (25) defines the total momentum already possessed when the particle is moving at constant speed respect the vacuum. In fact, in a lab can be measured only the time variation of the momentum (25) that at the first order gives the second Newton's law:

$$\frac{dP^{+}}{dt} \equiv \frac{dp}{dt} = ma \tag{26}$$

In general the complete Doppler equation (24) defines the relativistic momentum of the Galileo's principle for a particle in motion respect to the vacuum where, the momentum mc corresponds to the minimum Galilean momentum of a particle when it is at rest respect the vacuum, this momentum is due to the zitterbewegung of the particle around the own centre of mass, in other words an observer coinciding with the particle experiences a physical difference when it is at rest or in motion respect to the vacuum, a difference that can be measured by the Eq. (26). To conclude, the vacuum can be considered an absolute inertial reference frame respect which matter moves.

A. *Perturbations of the Galilean momentum*

Considering a perturbation of the relativistic momentum (24), the particle initially at rest respect to the vacuum reacts at the variation of the velocity with a force

$$F = \frac{dP^{+}}{dt} = \gamma^{3}(1+\beta)ma \tag{27}$$

which can also be broken in two terms:

$$F = \gamma^{3} ma + \frac{1}{c}\mathcal{P} \tag{28}$$

The first term of the Eq. (28) is the force associated to the longitudinal inertia of the particle along the direction of motion, the second term is associate to the power

$$\mathcal{P} = \frac{dE}{dt} = \gamma^{3}\beta\frac{d\beta}{dt}mc^{2} \tag{29}$$

necessary to increase the total energy $E = \gamma mc^{2}$ of the particle. This term becomes negligible for weak perturbations when $\beta << 1$, in this case the Eq. (27) or equivalently (28) agrees with the second Newton's law (26).

B. *Galilean and Relativistic Momenta of an inertial particle*

Considering the Galilean Doppler equation (24) rewritten in the form

$$P^{+} = \gamma mc + \gamma mv = \frac{E}{c} + p \tag{30}$$

in order to understand its meaning it is necessary to introduce the two four-momenta

$$\mathbf{P}^{+} = \frac{E}{c}\hat{\boldsymbol{\tau}} + \mathbf{p} \tag{31}$$

$$\mathbf{P}^{-} = \frac{E}{c}\hat{\boldsymbol{\tau}} - \mathbf{p} \tag{32}$$

The first represents the total momentum in time and space, the second, at time, is only an useful four-vector.

Using the Eq. (31) and (32) we write equivalently to the covariant form

$$\mathbf{P}^{+} \cdot \mathbf{P}^{-} \equiv p^{\mu} p_{\mu}$$

$$p^{\mu} p_{\mu} = \left(\frac{E}{c}\right)^{2} - p_{x}^{2} - p_{y}^{2} - p_{z}^{2} = (mc)^{2} \qquad 33)$$

where

$$\mathbf{p} = p_{x}\hat{\mathbf{i}} + p_{j}\hat{\mathbf{j}} + p_{z}\hat{\mathbf{k}} \tag{34}$$

from which the four-momenta (31) and (32) became:

$$\mathbf{P}^{+} = \sqrt{(mc)^{2} + p^{2}}\,\hat{\boldsymbol{\tau}} + \mathbf{p} \tag{35}$$

$$\mathbf{P}^{-} = \sqrt{(mc)^{2} + p^{2}}\,\hat{\boldsymbol{\tau}} - \mathbf{p} \tag{36}$$

It is evident as for a particle at rest with $p = 0$, the time-components of the four-vectors (35) and (36) are coinciding with the Galilean rest momentum mc produced by the zitterbewegung of the particle. In general the time-components of momentum describe the Galilean growing momentum γmc felt by the particle themselves under form of growing inertia. On the other hand, the space-components of the four-vectors (35) and (36) represent the mechanical momentum γmv of the particle, produced by its motion in space respect to an observer at rest. Taking together the two components respectively associated to the time and space dimensions, the two four-vectors (35) and (36) represent the momenta respect to an observer at rest both in time and in space. This frame is linked to the vacuum frame of reference that, in this sense it is an absolute reference frame equivalent to the

Galilean one of the fixed stars, which relative motion respect a particle is obeying to the invariant (33) that with the (30) allows to evaluate the momentum of a particle in the absolute frame of space-time [5, 13].

VI. PERTURBATIONS OF THE MOTION OF A MONO-ATOMIC HYDROGEN

Following the inertia model delineated in the previous paragraphs, a body perfectly neutral is not subject to inertia because is not able to produce DEMS with which to interact. On the other hand, in nature does not exist particles or matter really neutral, in fact all the hadrons have mass and charge and all the leptons manifesting inertia have charge. The neutrino is the only lepton that to obey the oscillation between its three flavours has probability to mantain a weak residual charge able to produce an inertia low enough to be considered a particle without mass able to move at the speed of light. On the other hand neutrons, neutral pions and all the not elementary neutral particles are formed by quarks, so locally they present residual electrical fields as also the atoms able to produce bound states with other atoms, consequently each non elementary particle and each bound state of matter as an atom is able to manifest inertia.

Considering a single atom of hydrogen, is possible to schematise and simplify the model considering it as a stationary null-dipole as presented in references [20] and [21]. Since using [19] the rest energy in the centre of mass of the hydrogen is given by

$$\begin{aligned}\varepsilon_H^2 &= E_H^2 - P_H^2 c^2 \\ &= \varepsilon_p^2 + \varepsilon_e^2 + 2\varepsilon_p \varepsilon_e \gamma_o\end{aligned} \tag{37}$$

where ε_p and ε_e are respectively the rest energies of the nucleus and of the orbital electron and γ_o is the Lorentz factor of the electron, the energy and momentum of an atom of hydrogen respect an external inertial observer are given by

$$\begin{cases} E_H = \gamma \varepsilon_H = \gamma \sqrt{\varepsilon_p^2 + \varepsilon_e^2 + 2\varepsilon_p \varepsilon_e \gamma_o} \\ P_H = \gamma\beta \dfrac{\varepsilon_H}{c} = \gamma\beta \dfrac{\sqrt{\varepsilon_p^2 + \varepsilon_e^2 + 2\varepsilon_p \varepsilon_e \gamma_o}}{c} \end{cases} \tag{38}$$

considering that in [20] the orbital speed of the electron is estimated to be

$$\beta_o = \frac{E_{spin}}{E} = \frac{2\pi \dfrac{e^2}{\lambda_0}}{2\pi \dfrac{\hbar c}{\lambda_0}} = \frac{e^2}{\hbar c} \equiv \alpha \tag{39}$$

where λ_o is the orbital radius of the electron, the Lorenz factor gives a typical not highly relativistic value

$$\gamma_o = \frac{1}{\sqrt{1-\alpha^2}} = 1.0000266 \cong 1 \tag{40}$$

with which the equation (38) becomes

$$\begin{cases} E_H = \gamma\left(\varepsilon_p + \varepsilon_e\right) \\ P_H = \gamma\beta \dfrac{\varepsilon_p + \varepsilon_e}{c} \end{cases} \tag{41}$$

from which the rest energy (37) yields

$$\varepsilon_H^2 = E_H^2 - P_H^2 c^2 \cong \left(\varepsilon_p + \varepsilon_e\right)^2 \tag{42}$$

As in the eq. (21), the total momentum is exchanged by each charge along the lines of the electric field with the other charge, as if that were uniformly distributed over the entire solid angle. Using the equation (3) and (42) the directional momentum yields

$$P_\Gamma \cong \frac{1}{8\pi} \frac{\sqrt{1-\beta^2}}{\left(1-\beta\cos\theta\right)} \frac{\left(\varepsilon_p + \varepsilon_e\right)}{c} \tag{43}$$

integrating respect all the directions of interaction characterising the A-phase of the moving hydrogen respect the universe and using the results (9), the definition (23), the total electromagnetic momentum exchanged between the hydrogen and the external vacuum is

$$\begin{aligned} P_A &\cong \int_0^{2\pi} d\varphi \int_0^{\pi/2} P_\Gamma d\theta \\ &= \frac{\varepsilon_p + \varepsilon_e}{4c} \sqrt{1-\beta^2} \int_0^{\pi/2} \frac{d\theta}{1-\beta\cos\theta} \\ &= \left(m_p + m_e\right) \tan^{-1}\left(\sqrt{\frac{1+\beta}{1-\beta}}\right) c \end{aligned} \tag{44}$$

Considering a variation of speed along the direction of motion, the inertia manifested during the action of an external force along the specific direction among all the directions of the solid angle is

$$m_H = \frac{dP_A}{dv} = \gamma\left(m_p + m_e\right) \tag{45}$$

Equation (44) and (45) prove as inertia is an additive property, so independently by the amount of particle or atoms in space, the total inertia is the sum of the inertia of each single particle, atoms or molecule.

VII. MOVING MATTER AT LOW INERTIAL RESISTANCE

Equation (6) it shows as a body moving at speed β in vacuum, it does not manifest an inertial behaviours only if it is able to interact with the surrounding vacuum along a precise angular direction $\theta_{pol} = \cos^{-1}\beta$. To do that it is necessary that the interactions with the vacuum of the external surface of the body occur only in that direction. A possibility is to force the pre-polarisation of the vacuum using an intense directional electric field that must emerge from the surface of the body in such a way that the angle formed between the local electric field of an element of surface and the direction of motion of the body is exactly equal to θ_{pol}.

Considering a solid body of resting mass M, from the Eq. (10) is possible to argue that if the interaction of each element of surface of the body occur within an angular interval $[0,2\pi]$ the resulting inertial behaviour is null. In fact, in this case if we considering a superconducting rotating sphere or disk, each point of the surface performs a trajectory on a circumference changing the angle of interaction in time. Considering the angle $\theta = \omega t$ Eq. (6) and (8) give

$$\mu_{2\pi} = \int_0^T \mu\omega dt = \gamma\frac{M}{2}\int_0^T \frac{\cos\omega t - \beta}{(1-\cos\omega t)^2}\omega dt = 0 \qquad (46)$$

which should correspond to the inertia of a rotating superconducting body.

VIII. CONCLUSIONS

The inertia is proved to be an emergent property of the charged particles. Its origin springs out from a new version of the Mach's principle, in which all space-time, originated by a stochastic distribution of dipole electromagnetic sources produced from the electromagnetic field of an early DEMS, interacts with real charge. The result is the building of an electromagnetic quantum-relativistic variant of the Dirac's ether, in which each DEMS represents a boson able exchanging energy and momentum between the real charge and space-time. The global effect is the production of a zitterbewegung of a real charge associated to a mean frequency of vibrate, with production of energy with which the trembling charge becomes a real particle. In this sense the model of space-time is an electromagnetic version of the Higgs model. Space-time is an absolute frame of reference in which all the particles move. If a particle is accelerated, the inertia is manifesting for effect of the exchange of energy and momentum between particle and space-time. In this context contrarily to Einstein thought, the inertia of a particle is not the Newtonian classical mass but its relativistic mass which is growing with the velocity in agreement with the Relativity Theory. Moreover the three Newton laws are obtained in their relativistic form and the application of the theory to the Galileo's principle shows as all the particles have a momentum at rest produced by their stochastic trembling respect to an absolute space-time. A proof on the additivity of the inertia of the particles of matter with a simple model of monatomic hydrogen is given. Using the model, is suggested a way to reduce the inertia of a moving body.

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