On Different Meanings of Mass in Physical Systems

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Abstract

Different physical definitions of mass are present in scientific literature. Mass has been always considered an important physical quantity for the study and for the description of dynamics of physical systems. Let us want now to underline also kinematic properties of mass, above all in regard to the physico-mathematical relationship between mass and time, and consequently the unlike physical behavior of systems due to different properties of mass, whether in the macroscopic domain or in the microscopic domain.

1. Introduction

We are starting from the real fact that several definitions of mass exist in physics.
Let us set out hence to clarify on those concepts and in case to see prospective overlappings and equalities. Physical system is considered here any material body which fills an empty physical space with non-null volume, consequently we exclude at least initially in our definition physical systems of pure energy. Let us consider the following concepts of mass that are present in scientific literature: resting mass, static mass, inertial mass, gravitational mass, dynamic mass, electrodynamic mass, relativistic mass, longitudinal mass, transversal mass, equivalent mass.
In this paper we will make use of fundamental concepts of the Theory of Reference Frames (TR) in which "*the physical speed of light c*" is a local constant: it means it has a constant value only in the local reference frame (preferred local reference frame) where the considered physical event happens and where the speed of light is measured, while with respect to all other reference frames in relative motion "*the relativistic speed* c_r" must be considered. It is variable and has vector nature, is obtained by the vector composition of the physical speed of light with the relative speed of the second reference frame with respect to the preferred and local reference frame[1][2].

2. Static mass and inertial mass

Concepts of static mass and inertial mass derive directly from the Generalized Principle of Inertia[1] that affirms:

"Every massive physical system tends to keep its resting state or its inertial motion state with respect to a reference frame supposed at rest, until an external cause or force changes its state".

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The Generalized Principle of Inertia establishes firstly an equivalence between the resting state and the inertial motion state and secondly the necessity to introduce a reference frame supposed at rest in order to define correctly the concept of inertial state that, in concordance with the Generalized Principle of Inertia, consists in a resting state or in a motion state, caused by no force or by forces with null total resultant, with respect to the reference frame supposed at rest.
The Generalized Principle of Inertia allows to define a "*resting mass*" m_o (or static mass) and an "*inertial mass*" m_i in inertial motion with respect to the resting reference frame and as per the same principle it is possible to deduce that static mass and inertial mass of the physical system coincide, that is $m_i=m_o$.
If the physical system, initially at rest or with inertial motion with respect to the resting reference frame, is subjected to the action of an external force F then, as per the Principle of Causality and the Principle of Action and Reaction, supposing that external resistant forces are null (k=0), the physical system responds with a resistant force of inertia (internal resistant force)[3] given by the Newton law

$$F = m_o \frac{dv(t)}{dt} \qquad (1)$$

Because the reaction force is a force of inertia, it is manifest the mass m_o in (1) is the static or inertial mass, which is also the mass that must be considered when external resistant forces are different from zero ($k\neq0$)[1][3].
Concepts of resting mass and inertial mass are valid also for elementary particles because also they respond with an acceleration, like mechanical classic bodies, when they are subjected to an electromagnetic force. But as we saw already in the Theory of Reference Frames[1] the dynamic behavior of elementary particles is altogether different. in fact charged elementary particles emit a quantum electromagnetic radiation which is instead absent in classic bodies, and it involves a different behavior of inertial mass[3][4][5].

3. Gravitational mass

The gravitational mass m_g is the mass with wich any material body responds to the action of the gravitational field, that in its turn is generated by a gravitational mass M_g, supposed static, where generally $m_g<<M_g$. The gravity force isn' t constant but it changes with the square of the distance r between the barycentre of the physical system which causes the gravity force (for instance the earth) and the barycentre of body which undergoes the gravity force.
In the event of small paths of the moving body it is possible to suppose the gravity force is constant in first approximation. The gravity force[1][3] is given by Newton' s law of gravitation, and in the event of the earth we have

$$F_g(r) = \frac{G\, m_T\, m_g}{r^2} \qquad (2)$$

where m_T is the mass, supposed static, of the earth, m_g is the gravitational mass of physical body, G [=6,67x10^{-11} Nm^2kg^{-2}] is the gravitational constant. The Newton gravitation force isn't a force at distance, as it was believed in classic physics, because of the gravitational potential that is present in all points of space from the first together with the static mass.
If the body is free, motion analysis for k=0 (absence of external resistant forces) gives with good approximation an unifomly accelerated motion in the initial part of motion (corresponding practically with constant gravity force), afterwards acceleration and speed increase quickly (as r decreases). In these conditions the motion law is independent of body mass and consequently is the same for all bodies. Therefore all bodies, with any nature and shape, fall similarly in the absence of external resistant forces (Newton's tube). Motion can be considered still with good approximation uniformly accelerated with respect to small paths in any part. If $k \neq 0$ (presence of external resistant forces) motion law depends on body mass and since bodies with different masses fall in different way.
Because gravitational force is in any case a force appied to body, we deduce in concordance with the Newton law that $m_g = m_i = m_o$ for classic bodies.
Elementary particles instead are characterized by a different concept of inertial mass which coincides with electrodynamic mass that changes with the speed[1][2][3][4].
Let's suppose that mass, in any shape, is sensible to gravitational force and therefore also particles are subjected to the action of gravitational field[6]. Let's calculate now values of the gravitational force of the earth at sea level for a few basic physical systems supposed in static or resting conditions.

physical system	static mass [Kg]	gravitazional force [N]
electron	9,11x10^{-31}	89,28x10^{-31}
proton	1,673x10^{-27}	16,395x10^{-27}
hidrogen atom	1,674x10^{-27}	16,405x10^{-27}
oxygen atom	26,6x10^{-27}	260,68x10^{-27}
hidrogen molecule	3,35x10^{-27}	32,83x10^{-27}
oxygen molecule	53,2x10^{-27}	521,36x10^{-27}
1 gram of matter	10^{-3}	9,8x10^{-3}

Tab.1 Values of static masses and gravitational forces for a few basic physical systems.

Considering that the radius of the earth isn' t constant but changes with the latitude, the gravity acceleration is $g=9{,}780 m/s^2$ at the equator and $g=9{,}831 m/s^2$ at poles.
Taking on a gravity average acceleration equal to $9{,}80 m/s^2$ we have values of tab.1.

It is possible to see in table that proton and, atomic and molecular matter have static masses and gravitational forces round the same order of magnitude while electron has a static mass and a gravitational force smallest with respect to atomic and molecular matter. Ordinary matter has instead static masses and gravitational forces much bigger.
It is interesting to calculate attractive electric force F_{er} generated in the electromagnetic field by the charge of one proton acting on one free electron which is at distance equal to the average radius of the earth (r_m=6367Km)

$$F_{er} = \frac{e^2}{4\pi\varepsilon_o r^2} = 5{,}6 \times 10^{-42} N \qquad (3)$$

Comparing the gravitational force of the earth F_g on electron at sea level and the electric force F_{er} produced by one proton on the same electron at the same distance of the average radius of the earth, it follows that at the same distance the gravitational force is much bigger. In fact

$$F_g \approx 1{,}59 \times 10^{12} F_{er} \qquad (4)$$

This result would seem completely different from the common convinction that the gravitational force is a weak force with respect to other fundamental forces.
It is necessary nevertheless to specify that electromagnetic field, through the Coulomb force acts on electron at smallest atomic distances ($r \approx 100$pm), and at these distances the electromagnetic force F_{ea} has about following values

$$F_{ea} \approx 2{,}3 \times 10^{-8} N \qquad (5)$$

which is much bigger than the gravitational force acting on electron at distance of earth radius. In fact

$$F_g \approx 38{,}82 \times 10^{-23} F_{ea} \qquad (6)$$

At unit distance (≈1m) the electromagnetic force $F_{eu} \approx 2{,}3 \times 10^{-28} N$ is still greater than the gravitational force, but now the two forces are comparable, in fact

$$F_g \approx 0{,}039 F_{eu} \qquad (7)$$

From (6) we deduce gravitational field has very negligible effects with respect to atomic structure in which electron is tight bound to nucleus. From (7) nevertheless we derive that gravitational force acting on free electron along earth' s surface has comparable values (equal to 4%) with electromagnetic force acting at unit distance and therefore gravitational field exercises a non-negligible action on the free electron.
The same reasoning is valid also for one antiproton, in place of electron: in fact in that case the attractive electric force of the proton F_{pr} on the free antiproton at the distance of the earth' s radius is equal to F_{er}. In table 1 we have calculated the gravitational force F_{gp} at sea level, because proton and antiproton have the same resting electrodynamic mass, we deduce that

$$F_{gp} \approx 2,93 \times 10^{15} F_{pr} \qquad (8)$$

for which, like it was predictable, $F_{gp} \approx 1836 F_g$. The gravitational force on antiproton at sea level is biggest with respect to the the electric force produced by proton on antiproton at the same distance of the earth radius. Calculating the electric force F_{pu} on free antiproton at unit distance, being $F_{pu}=F_{eu}$, we have

$$F_{gp} \approx 71 F_{pu} \qquad (9)$$

From (9) we deduce that gravitational force acting on free antiproton at sea level is greater than the electromagnetic force acting at unit distance always on the same antiproton and consequently it has an important effect on the considered process.

4. Dynamic mass

The concept of dynamic mass[3] is a virtual concept, physically non-real but useful, that has a meaning specially for mechanical massive systems. These systems when are accelerated, unlike elementary particles, don' t emit radiant energy. Let's take on that the concept of intrinsic energy[1][3][4] is valid, always virtually, also for these systems for which if a classic system has a static mass m_o , it has also a virtual intrinsic energy

$$E_{io} = m_o c^2 \qquad (10)$$

Because the body accelerated to the speed v acquires a kinetic energy $E_c=m_o v^2/2$, it has a total energy

$$E_t = E_{io} + E_c = m_o c^2 + \frac{1}{2} m_o v^2 \qquad (11)$$

Putting $E_t=m_d c^2$ in which m_d is the *"dynamic mass"* , that is a virtual concept of mass, the (11) becomes

$$E_t = m_d c^2 = m_o c^2 + \frac{1}{2} m_o v^2 \qquad (12)$$

and from here

$$m_d = m_o \left(1 + \frac{1}{2} \gamma^2\right) \qquad (13)$$

where γ=v/c.

It is possible to chart the trend of dynamic mass with the speed, obtaining the graph of fig.1. Dynamic mass is always positive, it equals $1,5m_o$ for v=c and at the critical speed $v_c=\sqrt{2}c$ equals $2m_o$.

It is necessary to underline once again the variation of mass of a mechanical system with the speed isn' t real because the virtual increase of mass is due to the kinetic energy of the system with static mass m_o and therefore from a relativistic viewpoint we can affirm that a mechanical system with static mass m_o and speed v is equivalent to a resting system with static mass m_d.

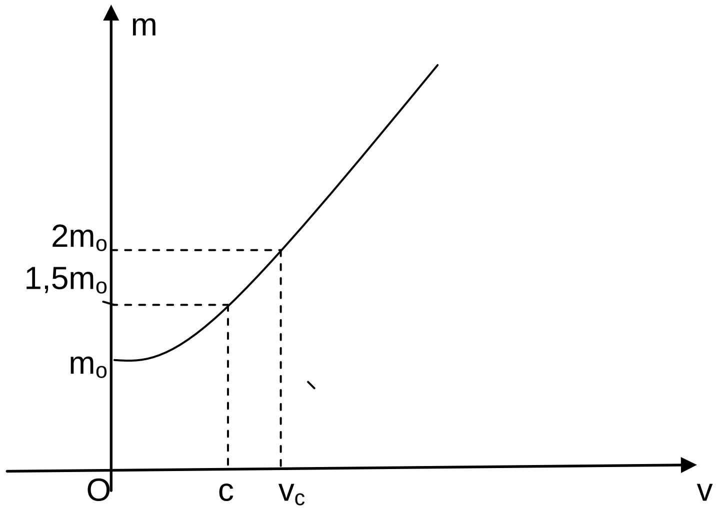

Fig.1 Parabolic increasing trend of dynamic mass at changing of the speed.

In the order of the Theory of Reference Frames dynamic mass of ordinary bodies is therefore a virtual physical concept, useful in some physical situations, unlike electrodynamic mass of elementary particles that instead is a real physical concept.

5. Transversal mass and longitudinal mass

In Special Relativity mass of any massive system changes with the speed v generating a vector mass with three space components: one component is longitudinal towards motion and other two components are equal, transversal and perpendicular to motion direction. Transversal mass m_t in SR is given by

$$m_t = \frac{m_o}{\sqrt{1 - \gamma^2}} \qquad (14)$$

where still γ=v/c.

Longitudinal mass m_l , towards motion, is given instead by

$$m_l = \frac{m_o}{\sqrt{(1 - \gamma^2)^3}} \qquad (15)$$

We have demonstrated inconsistency[1][7] of these concepts of transversal mass and longitudinal mass that would generate a preposterous vector mass.

Comparing virtual dynamic mass in TR with transversal mass in SR we see that for γ <<1 (v<<c) dynamic mass differs from transversal mass for terms of fourth and greater order.

5. Electrodynamic mass and relativistic mass

Electrodynamic mass is a concept defined and used in the Theory of Reference Frames[1][3][4][5] and it is valid exclusively for charged massive elementary particles that undergo electromagnetic interaction. So this concept doesn't have meaning for classic bodies, considered in preceding paragraphs, because they undergo only mechanical or gravitational forces.
The concept of electrodynamic mass derives from the observation that accelerated charged elementary particles emit electromagnetic energy in quantum shape and it can happen only at the expense of an intrinsic property of particles, that we called[1][2] *"electrodynamic mass"*, which represents the fundamental massive feature of elementary particles. The physical property of elementary particles of emitting electromagnetic energy in quantum shape, when they are accelerated, can be explained in satisfactory way by laws of electromagnetic field. In fact electric current is composed of an electron flow (that is the number of electrons which cross a section in a time interval): a constant flow produces a constant current which generates a constant magnetic field, a variable flow produces a variable current which generates a variable electromagnetic field that radiates electromagnetic energy in continuous way. The single electron sets up a nanocurrent whose variability cannot depend, like in the event of electric current, on the number of electrons but only on variation of speed (accelerated electron): therefore an accelerated electron emits electromagnetic energy.
Nevertheless while electromagnetic energy emitted by an variable current is a continuous phenomenon, electromagnetic radiation emitted by an accelerated electron (nanocurrent) is a quantum phenomenon: we have demonstrated it in references [1],[3],[4],[5].
When particle is accelerated to the speed of light c it emits a first gamma quantum and, further accelerated, a second gamma quantum (equal to the first) at the critical speed v_c=1,41c. These quantum emissions of energy happen at the expense of electrodynamic mass of particle which is zero at the critical speed and it becomes negative (antimass) at greater speeds than the critical speed.
A charged elementary particle in the resting state has an intrinsic energy $E_{io}=m_oc^2$ in which m_o is the resting electrodynamic mass and c is the *"physical speed of light"* (local constant). Particle accelerated to the speed v acquires an equivalent kinetic energy $E_c=m_ov^2/2$ and its electrodynamic mass decreases because of the quantum emission of electromagnetic energy for an amount equivalent to the kinetic energy. The intrinsic energy at the speed v becomes therefore $E_i=mc^2$ where m is the electrodynamic mass at the speed v. Applying the Conservation Principle of Energy we have

$$E_{io} = E_i + E_c \qquad (16)$$

from wich we deduce electrodynamic mass changes with the speed according to the following relation

$$m = m_o \left(1 - \frac{1}{2}\frac{v^2}{c^2}\right) \qquad (17)$$

Mass m given by the (17) is the *"relativistic electrodynamic mass"* of particle.
As per this elementary particles don' t have a constant inertial mass with the speed, like it happens for mechanical classic bodies, but their inertial mass, coinciding with electrodynamic mass, changes with the speed according to a decreasing parabolic trend which has the maximum in the vertex for v=0 (fig.2). The phenomenon of electromagnetic emission has quantum nature as we have demonstrated.
Electrodynamic mass is positive and decreasing to the critical speed $v_c=\sqrt{2}c$, halves for v=c and vanishes for $v=v_c$. For greater speeds than the critical speed electrodynamic mass becomes negative (antimass) generating all unstable charged particles that undergo decay known processes[5][8][9][10].

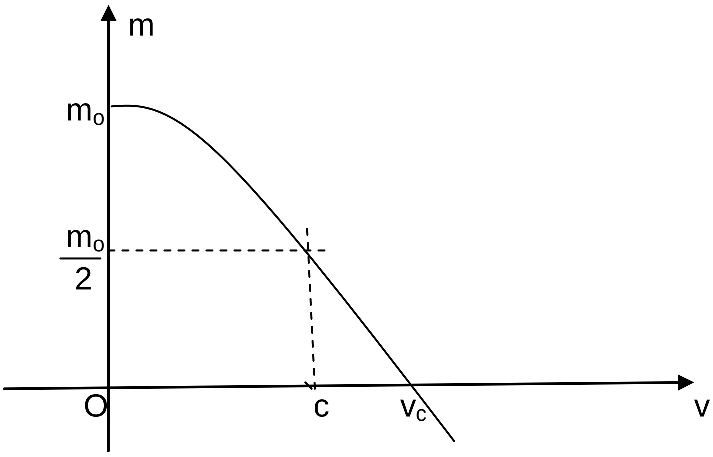

Fig.2 Decreasing parabolic trend of relativistic electrodynamic mass at changing of the speed, m_o is the resting electrodynamic mass of particle.

As per our knowledges we can deduce that a direct relationship between electrodynamic mass and electric charge doesn' t exist: in fact electron and proton, for instance, have the same absolute value of electric charge and the same intrinsic angular momentum (spin), but they have different electrodynamic mass (resting proton has a mass equal to 1836 times mass of resting electron). We know instead that a direct relationship between spin and electric charge exist as per the Theorem of Electric Charge and Spin[5][9].
It is possible then to establish a relationship among electrodynamic mass m, radius r, intrinsic angular speed ω and spin q_s for the single particle.
In fact if q_{se} and q_{sp} are intrinsic angular momentums (spin) of electron and proton, for k=1 (free particle in the fundamental state) and in absolute value, we have

$$q_{se} = J_e \omega_e r_e = m_e \omega_e r_e^3 = \frac{h}{4\pi} = \frac{\hbar}{2\pi} \quad (18)$$

$$q_{sp} = J_p \omega_p r_p = m_p \omega_p r_p^3 = \frac{h}{4\pi} = \frac{\hbar}{2\pi} \quad (19)$$

in which m_e and m_p, ω_e and ω_p, r_e and r_p are electrodynamic mass, intrinsic angular speed, radius respectively of electron and proton.

Comparing the (18) with the (19), being $q_{se}=q_{sp}$, we have

$$\omega_e = \frac{m_p r_p^3}{m_e r_e^3}\ \omega_p \qquad (20)$$

from which we deduce $\omega_p < \omega_e$.
Atom-bound electron has also an orbital angular momentum q_o that in the fundamental level (k=1) is

$$q_o = \frac{h}{2\pi} = 2\ q_{se} \qquad (21)$$

This momentum doesn' t exist for proton.

6. Equivalent wavelength of massive particles and equivalent mass of energy particles

For massive elementary particles it is possible to define an equivalent wavelength as per De Broglie's relation, for which an elementary particle with electrodynamic mass m_o at the speed v has a momentum $p=m_o v$ and therefore a De Broglie's equivalent wavelength

$$\lambda = \frac{h}{p} = \frac{h}{m_o v} \qquad (22)$$

De Broglie's equivalent wavelength depends on the speed v of massive elementary particle besides on its resting electrodynamic mass.
Compton introduced a different equivalent wavelength λ_c for a massive particle[4]. This wavelength, so-called Compton's wavelength, is correlated with intrinsic energy of particle $E=m_o c^2$ rather than with momentum. In that case, being $E=hf_c$, we have

$$f_c = \frac{m_o c^2}{h} \qquad (23)$$

and therefore

$$\lambda_c = \frac{h}{m_o c} \qquad (24)$$

Compton's wavelength depends only on resting electrodynamic mass of massive particle.
Comparing the (22) with the (24), we deduce

$$\lambda_c = \lambda \frac{v}{c} \qquad (25)$$

Similarly energy particles are energy quanta that don't have a real mass. It can be useful in that case to define a virtual equivalent mass m_{eq}; it is manifest that this virtual equivalent mass has electrodynamic nature.
Any energy quantum has an energy E=hf in which f is frequency of corresponding electromagnetic nanowave, and it is included between infrared radiation and delta-Y radiation.
For every energy quantum we can consider an equivalent virtual massive particle whose resting electrodynamic mass m_{eq} generates an intrinsic energy $E=m_{eq}c^2$. Equalling the two energies we have

$$m_{eq} = \frac{hf}{c^2} = \frac{h}{\lambda c} = \frac{p}{c} \qquad (26)$$

where λ and p are wavelength and momentum of nanowave.
Comparing the (24) with the (26) we can deduce that equivalent resting electrodynamic mass of an energy particle is connected with Compton' s wavelength rather than with De Broglie' s wavelength.
Applying to equivalent mass of a typical photon with frequency $f=10^{15}$Hz the Newton gravitational law at sea level on the surface of the earth, we achieve a value of gravitational force $F_g=7{,}25\times10^{-35}$N, that is a smallest value with respect to those in tab.1.
We can confirm therefore that a gravitational action on light and on energy quanta exists, as we already know[6], but it is smallest.

7. Mass and time

Dynamic mass and equivalent mass are virtual masses and therefore they aren't real masses but have only a virtual meaning in the order of the considered equivalence.
Static mass, inertial mass and gravitational mass coincide relative to classic mechanical systems. Electrodynamic mass has meaning only for elementary particles and not for classic mechanical systems. Resting electrodynamic mass coincides with static mass but relativistic electrodynamic mass, variable with the speed, is different from classic inertial mass that instead is constant with the speed. Gravitational mass has a precise and known physical meaning for classic mechanical bodies while its meaning is less visible for elementary particles.
According to the Standard Model all mass of the universe would have same roots in an only boson with very high energy, about 125GeV. This boson, so-called Higgs boson, woud have extraordinary physical properties deriving from a scalar field, that formed billionths of second after the great explosion of the big bang and it would have given to this particle exclusive properties as mather of the universe. This mechanism nevertheless is unable to explain in satisfactory way the appearance of the scalar field and the diversification of matter into numerous particles present in nature.
In the Non-Standard Model this boson, observed in CERN Laboratories[11] (ATLAS and CMS Projects), is a strongly unstable particle, belonging to the leptonic subfamily of positronium[11].

It has compatible physical properties with other unstable particles; it has the feature of having highest values of energy and therefore of decaying in a briefest time, but it doesn' have, always in NSM, the extraordinary property to be mather of the whole universe and to give mass to all other particles. In future certainly other unstable particles at greater energy, belonging whether to leptonic family or baryonic family, will can to be observed.
In the Theory of Reference Frames we have demonstrated the following equations of transformations of space-time for all moving reference frames, that are provided with any speed with respect to the reference frame supposed at rest[1][11] .

$$\mathbf{P}[x,y,z,t] = \mathbf{P}[x',y',z',t'] + \int_0^t \mathbf{u}\, dt$$

$$dt = \frac{m}{m'} dt' \qquad (27)$$

In (27) P[x,y,z] represents the material point in the reference frame supposed at rest S[O,x,y,z,t,m] and P[x',y',z'] represents the same material point in the moving reference frame S'[O',x',y,'z',t',m'] with any speed u with respect to S, m and m' are masses of the material point with respect to the two reference frames.
The (27) say in the empty universe, that coincides with the empty geometric space[1] (x,y,z), time doesn' t have reason to exist. Physical time t had a physical meaning only after the appearance in the space-universe of mass. At the appearance of mass (initial physical universe) and in the absence of motion (u=0), being m'=m, the second of (27) says dt=dt' and therefore t'=t. Namely time t of the initial physical universe and time t' of a hypothetical observer coincided. The appearance of motion (u≠0) generated the relativistic mass that in the event of electrodynamic systems produced a change of mass according to the relation

$$m = m' \left(1 - \frac{u^2}{2c^2}\right) \qquad (28)$$

from which

$$dt = \left(1 - \frac{u^2}{2c^2}\right) dt' \qquad (29)$$

$$t = \int_0^t \left(1 - \frac{u^2}{2c^2}\right) dt' \qquad (30)$$

For constant speed u we have

$$t = \left(1 - \frac{u^2}{2c^2}\right) t' \qquad (31)$$

The (28), (30) and (31) prove that a variation of mass with the speed produces a time relativistic effect that consists in a virtual contraction (in the considered model) of characteristic time t' of moving electrodynamic system with respect to the resting reference frame. It is valid nevertheless only for electrodynamic systems, in fact for ordinary classic systems (mechanical, electromagnetic, optical) there isn' t variation of mass.
Therefore relativistic time concerns only events and reference frames conditioned by the physical behavior of mass and doesn' t concern general reference frames in which time proceeds synchronous.
These considerations on time and mass have nothing in common with controversies on absolute time, that is a metaphysical concept, while here we are considering physical time, that isn't an inborn idea but it is based on experimental evidence.

Note
While I was intent to complete this article, I learned by the same author, Louis Roncart, through a communication in a topic of ResearchGate, his experimental work[12] regarding the action of light on mass. This effect can be considered the reciprocal effect of the action of the mass on light. The first impression is that those experiments are innovative and interesting for which they require further and greater elaborations also in order to study new developments of results.

References

[1] D. Sasso, Physico-Mahematical Fundamentals of the Theory of Reference Frames, viXra.org, 2013, id: 1309.0009

[2] D. Sasso, If the Speed of Light is Not an Universal Constant According to the Theory of Reference Frames: on the Physical Nature of Neutrino, viXra.org, 2011, id: 1110.0007

[3] D. Sasso, Dynamics and Electrodynamics of Moving Real Systems in the Theory of Reference Frames, arXiv.org, 2010, id: 1001.2382

[4] D. Sasso, Relativity and Quantum Electrodynamics in the Theory of Reference Frames: the Origin of Physical Time, viXra.org, 2011, id:1109.0018

[5] D. Sasso, On Primary Physical Transformations of Elementary Particles: the Origin of Electric Charge, viXra.org, 2012, id:1202.0053

[6] D. Sasso, Not Linear Element, Cosmological Redshift and Deflection of Light in the Gravitational Field, viXra.org, 2011, id: 1111.0036

[7]D. Sasso, Short History of Relativity, viXra.org, 2013, id: 1311.0071

[8] D. Sasso, On the Stability of Electrodynamic Particles: the Delta Radiation, viXra.org, 2012, id: 1210.0002

[9] D. Sasso, Physical Nature of Mesons and Principle of Decay in the Non-Standard Model, viXra.org, 2012, id: 1212.0025

[10] D. Sasso, On Basic Physical Properties of Baryon Matter According to the Non-Standard Model, viXra.org, 2013, id: 1302.0097

[11] D. Sasso, Bosons in the Zoo of Elementary Particles, viXra.org, 2013, id: 1305.0035

[12]L. Roncart, Why I believe that light can decrease gravity and why gravity is a pushing force, 2012, ResearchGate.net