On Physical Behavior of Elementary Particles in Force Fields

*Daniele Sasso **

Abstract

The physical behavior of elementary particles, massive and energetic, in force fields is studied in this paper. In particular let us consider the gravitational field and the electrostatic field and relative to the electrostatic field, as already it was done for the gravitational field, we demonstrate the theoretical validity of an electrostatic perturbation due to the motion of an electric charge into the electrostatic field generated by a pole charge. This electrostatic perturbation, on a pair with the gravitational perturbation, has characteristics of continuity differently from electromagnetic radiation, emitted by accelerated charges, free or constrained in complex structures, that instead has quantum characteristics.

1. Introduction

The object of this paper is that of expanding on the knowledge of the behavior of elementary particles, whether energy or mass, in force fields.
Energy quanta have a constant local physical speed c with respect to the preferred inertial reference frame where they move and have a variable vector relativistic speed with respect to any relative moving inertial reference frame. The relativistic speed is given by the vector sum of the constant local physical speed with the relative speed of the two reference frames. The same behavior is valid also for light, that is composed of photons, and in general for electromagnetic waves.
Charged elementary particles have an electrodynamic mass that is constant at rest and changes with the speed, unlike classical massive systems whose inertial mass is constant with the speed. It involves charged elementary particles have a relativistic inertial mass that depends on the speed and it is constant till the speed is constant.
We know besides accelerated charged elementary particles inside a force field have electrodynamic mass that decreases when the speed increases. Mass becomes zero at the critical speed v_c=1.41c , and becomes negative (antimass) at greater speeds than the critical speed where elementary particles become unstable.
We will consider in the first place the inertial field, successively the uniform force field and at last the non-uniform force field. In regard to non-uniform fields we will consider the gravitational field and the electrostatic field, that both have central symmetry.

* e_mail: dgsasso@alice.it

2. Behavior of elementary particles into the inertial field

In the Theory of Reference Frames[1][2] the Space-Time-Mass Domain is composed of three autonomous physical quantities, linked mathematically: the three-dimensional physical space, the one-dimensional physical time and mass from which the physical time originates[3]. In that domain the inertial field is represented by all reference frames with inertial motion with respect to an inertial reference frame supposed at rest S[O,x,y,z,t]. For any moving inertial reference frame S'[O',x',y',z',t'] with constant linear vector speed **v** with respect to S, transformation equations of the space-time-mass are

$$\mathbf{P}[S] = \mathbf{P'}[S'] + \mathbf{v}\,t$$
$$dt = \frac{m}{m'}\,dt' \qquad (1)$$

Suppose that motion with constant speed v with respect to S happens along a radial direction r (fig.1), then because of the spherical symmetry we have

$$r^2 = x^2 + y^2 + z^2 \qquad (2)$$

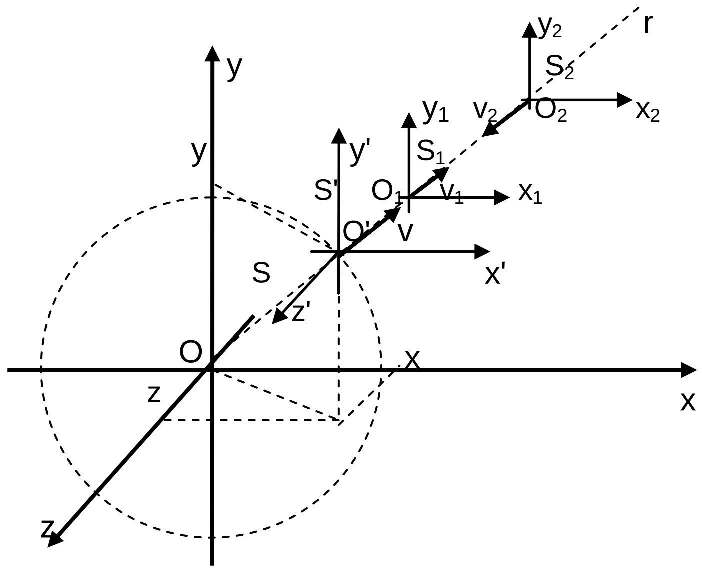

Fig.1 Motion with spherical central symmetry in the inertial field for different reference frames

Suppose still that at the initial instant t=0 the moving system is in the origin O, the constant scalar speed v is given by v=r/t. In that case it is possible a graphic representation of the inertial motion on the Minkowski two-dimensional plane (O,r,t) with origin in the point O.

2.1 If the moving system S' with speed v is an energy quantum, and if we assume symbolically that the physical speed v=c of the quantum with respect to S equals 1, then the space in metres covered by the quantum with respect to S equals the time in seconds spent for covering it and the speed of light is represented in the Minkowski graph by the bisector of the first quadrant, for which $\alpha'=45°$ (fig.2).

The straight lines c_1 and c_2 represent always in the same graph the relativistic speeds of both light and quanta with respect to two moving reference frames $S_1[O_1,x_1,y_1,z_1,t_1]$ and $S_2[O_2,x_2,y_2,z_2,t_2]$ with relative speeds v_1 and v_2 along the same radial direction.
In the graph of fig.2 the reference frame S_1 has a concordant speed v_1 with the physical speed of light for which the relativistic speed of quanta with respect to S_1, for (1), is given by

$$c_1 = c - v_1 < c$$
$$c_1 = tg\alpha_1 < tg\alpha' = c \qquad (3)$$

The reference frame S_2 has instead a discordant speed v_2 with the physical speed of quanta for which the relativistic speed, always for (1), is given by

$$c_2 = c + v_2 > c$$
$$c_2 = tg\alpha_2 > tg\alpha' = c \qquad (4)$$

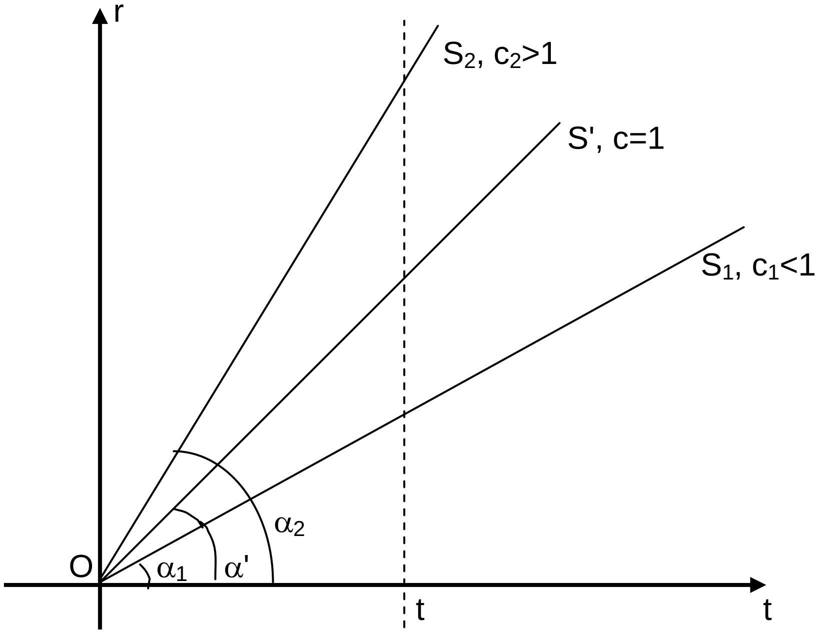

Fig.2 Minkowski's kinematic graph relative to energy quanta in the inertial field

2.2 Massive elementary particles have a dynamic behavior defined by the electrodynamic mass that changes with the speed causing as per the second of (1) a relativistic effect on particle's time.
Supposing that particle moves along the radial direction r with constant speed $v=r/t$ with respect to the resting reference frame S. If in the moving reference frame S' the resting constant electrodynamic mass is $m'=m_o$ and particle's time is t', with respect to the supposed at rest reference frame S we have

$$m = \left(1 - \frac{v^2}{2c^2}\right) m' \quad (5)$$

$$t = \left(1 - \frac{v^2}{2c^2}\right) t' \quad (6)$$

The Minkowski diagram (O,r,t) for different constant values of v is given in fig.3, where t and m are graphed on the horizontal axis, and r is graphed on the vertical axis,
The graph develops in full in the first and in the third quadrant of the Minkowski plane.
In particular we observe in the first quadrant ($v<v_c$) values of t,m,r are positive, in the third quadrant ($v>v_c$) are negative and they become zero in O at the critical speed $v_c=\sqrt{2}\,c$.

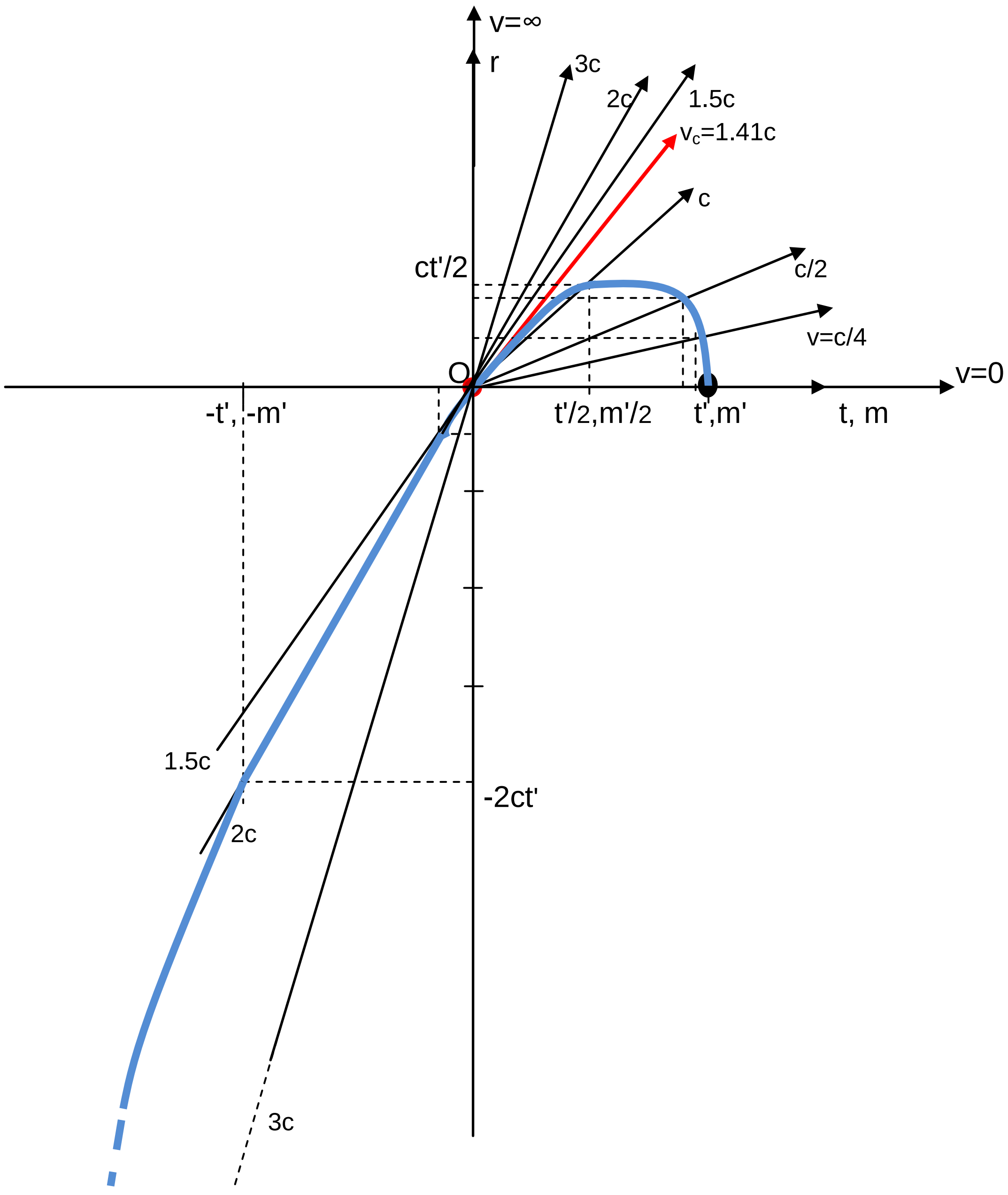

Fig.3 Minkowski's kinematic diagram relative to the motion of elementay particles in the inertial field

We can draw important physical meanings from the Minkowski diagram, that are altogether coherent with physical data of the Feynman linear diagram[4][5] in fig.4

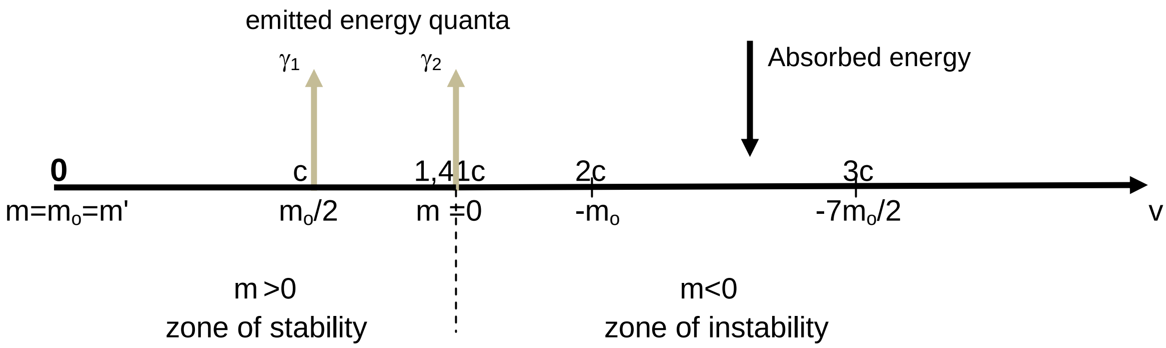

Fig.4 Feynman's linear diagram relating to the behaviour of the accelerated particle.

In the first quadrant of Minkowski's diagram, where the particle's speed is smaller that the critical speed, the particle has positive electrodynamic mass m, positive characteristic time t and positive covered distance r=vt: in these conditions the particle is stable. At the critical speed (origin O of axes) all values become zero and the particle is on the verge of stability. In the third quadrant the particle's speed is greater than the critical speed, characteristic values of m, t, r are negative, the particle is unstable and its degree of instability increases with the speed.
The existence of the particle in the third quadrant, characterized by instability, proves that negative values of electrodynamic mass (antimass), negative characteristic time and negative covered distance are physically possible. Let us remind that in physics negative quantities are real and therefore physically possible: they don't generate problems unlike imaginary quantities. In particular the negative electrodynamic mass, as we know, generates instability of the particle. The negative covered distance is physically altogether consistent with the (2). Negative times, on a pair with mass, indicate particle's instability; when it is free the instability has a briefest duration, with a quick return to the stability state and to the positive inertial time.
These considerations demonstrate that a stable universe exists in which time goes on in accordance with the positive flow past-present-future of time. They prove also that an unstable universe exists in which the passage from stability to instability is characterized by a time reversal with negative time intervals and the inverse passage from instability to stability is characterized by the return to the positive inertial time.

3. Behavior of elementary particles in the uniform field

The uniform force field is a field in which considered reference frames are accelerated in uniform way (constant acceleration) through a constant force with respect to the reference frame S supposed at rest (in our reasonings we don't consider prospective external resistant forces). In that case transformation equations of the space-time (1) become

$$\mathbf{P}[S] = \mathbf{P}[S'] + \frac{\mathbf{a}\,t^2}{2}$$

$$dt = \frac{m}{m'}\,dt' \qquad (7)$$

where **a** is the constant acceleration of the moving reference frame S' with respect to the reference frame S supposed at rest. Supposing that, like in the case of inertial field, also now the motion of S' happens along the radial direction r of S and that at the initial instant of time t=t'=0 the moving system is in the origin O with null initial speed, the constant acceleration is given by a=v/t from which v=at.
In that case the graphic representation of accelerated motion of S' in the Minkowski bidimensional kinematic plane (O,r,t) with origin in the point O is parabolic (fig.5) being

$$r = \frac{at^2}{2} \qquad (8)$$

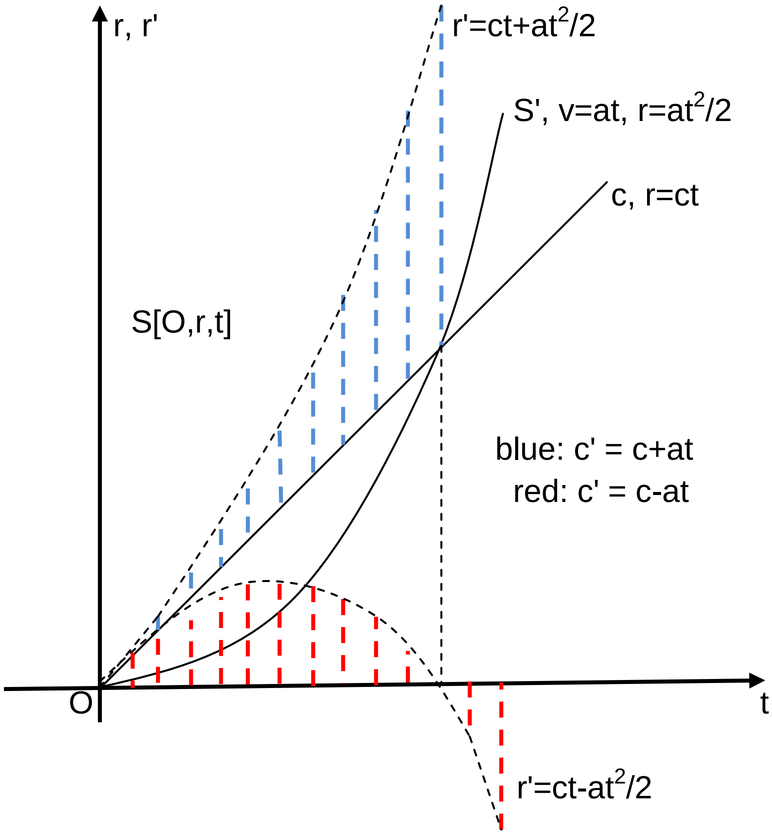

Fig.5 Minkowski's kinematic graph of motion of a quantum in an uniform force field

3.1 For energy quanta that travel with the physical speed c with respect to the reference frame S supposed at rest, the relativistic speed, with respect to the reference frame S' that is provided with an uniform accelerated motion **a**, is given by $c' = c \pm at$ (9)
in which t'=t, as per the (7), because energy quanta don' t have a variable real physical mass. The sign $\pm$ depends on the fact that the speed v of S' can be discordant or

concordant with the direction of the photon physical speed. The performed space is given by $r'=ct \pm at^2/2$ (+ in blue and - in red).

3.2 Let us consider now the case in which a massive elementary particle moves along a radial direction r with constant acceleration a and velocity v=at with respect to the resting reference frame S. If m' is the resting electrodynamic mass and t' is the particle time in the moving reference frame S', with respect to the resting reference frame S we have

$$m = \left(1 - \frac{a^2t^2}{2c^2}\right) m' \qquad (10)$$

$$dt = \left(1 - \frac{a^2t^2}{2c^2}\right) dt' \qquad (11)$$

where m and t are the electrodynamic mass and the time of elementary particle in S. Setting in the (11) $k_t=a/\sqrt{2}c$ and integrating we have[6]

$$t = \frac{1}{k_t} \,\mathrm{tgh}(k_t\, t') \qquad (12)$$

with t<t'. Charting in the Minkowski kinematic diagram the values of t, m, r for different values of v=at, we obtain a similar graph to diagram of fig.3.

4. Behavior of elementary particles in the non-uniform field

Supposing acceleration changes with linear law $\mathbf{a}(t)=\mathbf{Y}t$ where $\mathbf{Y}[Y_x,Y_y,Y_z]$ is a vector constant[7], transformation equations of the Space-Time-Mass domain become

$$\mathbf{P[}S\mathbf{]} = \mathbf{P'[}S'\mathbf{]} + \frac{\mathbf{Y}\, t^3}{6}$$

$$dt = \frac{m}{m'}\, dt' \qquad (13)$$

In that case, we have proved[7] the graph of the non-uniform accelerated motion on a two-dimensional plane (O,x,t) with origin in the point O is represented by cubic parabolas instead of quadratic parabolas. Consequently the relativistic behavior of physical systems into the field of non-uniform force is similar to the behavior into the field of uniform force and therefore the Minkowski kinematic diagram in that situation is still similar to the diagrams represented in fig3 and in fig.5.

Let us want to expand on the behavior of elementary particles relative to two particular non-uniform fields: the gravitational field and the electrostatic field (in that case only for charged massive particles). Both fields have central symmetry and aren't uniform because their intensity changes with the distance.

4.a The gravitational field

Let us distinguish still energy particles from massive particles.

4.a.1 Suppose that quantum energy particle comes from an inertial field with the constant physical speed c_o and goes into a gravitational field generated by a pole mass M_o (fig.6). In general the direction of the speed of the quantum can be any, but let us consider two particular cases: radial direction and tangential direction.

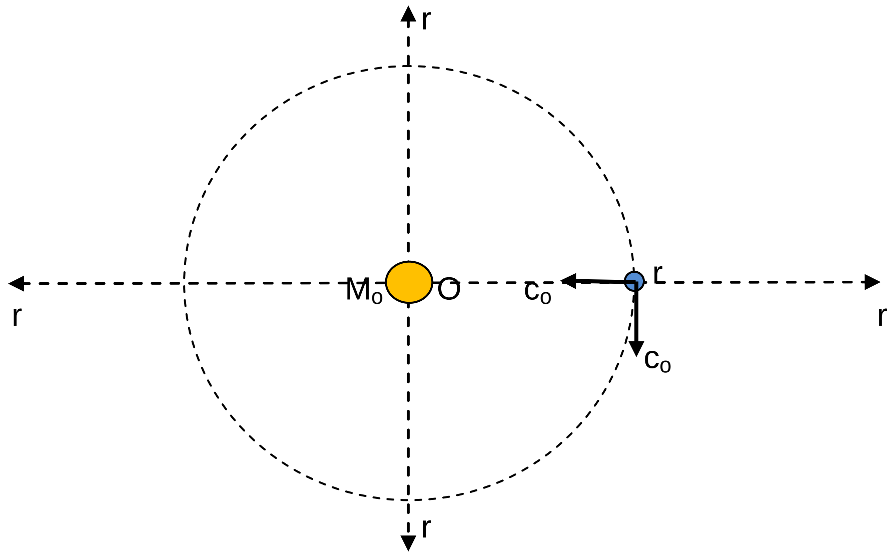

Fig.6 Representation of an energy quantum coming from two particular directions

Supposing that the quantum (provided with energy hf) comes from infinite (greatest) distance, because of both its equivalent mass $m_f=hf/c_o^2$ and the action of the gravitational field generated by the pole M_o, the quantum undergoes an attraction force that in the event of radial direction produces a variable radial speed, given[1][8] by

$$c(r) = \sqrt{c_o^2 + \frac{2GM_o}{r}} \qquad (14)$$

In the event of tangential direction the quantum undergoes a deflection[8] with respect to the pole M_o, that being α_o=90°, on the surface of the mass M_o, at distance R (n=1), is given by

$$\Delta = \frac{2GM_o}{c_o^2 R} \qquad (15)$$

where R is the radius of the pole M_o. In the event of the sun Δ=0,873 arcseconds, while for the earth $\Delta=0{,}287\times10^{-3}$ arcseconds. We note that the value of gravitational deflection Δ here calculated for the sun is different from the value calculated in the ref[8].
The difference of values is due to different used reference frames. In fact in the ref[8] values have been calculated with respect to the earth's observer.

I would want to consider now an open important question: does the deflection of quantum electromagnetic radiations in gravitational fields depend on frequency?
From the (15) we deduce the deflection is independent of frequency.
The question is equivalent to another question: that is if the fall of bodies in gravitational fields depends on mass of body. This question has been debated at length since Galileo's time and still today a sure answer to this question doesn' exist relative to known main theories: the Newtonian Dynamics and the Einsteinian Electrodynamics.
For this reason I would want to give an answer in the order of the Theory of Reference Frames. In TR the complete law of motion is not given by the only Newton law that represents the internal resistant force (F=mdv/dt) but it needs to consider also the external resistant force. In that event of the fall of bodies in gravitational fields the external resistant force is defined by atmosphere of celestial body that generates the gravitational field. When the atmosphere is present (like for the earth, the sun, etc..) then the fall of bodies depends on the body mass[2][6]. In a vacuum instead, and for celestial bodies that are devoid of atmosphere, the fall of bodies is independent of the mass of body. Therefore the fall of bodies relative to the earth, the sun and all other celestial bodies that have atmosphere, depends on mass of falling body.
As per this analogy what we can say about the dependence on frequency of the deflection of quantum electromagnetic radiations?
We know quantum radiations, for all frequencies as from infrared rays, are physical events of pure energy and in the order of the Theory of Reference Frames the deflection of those radiations in gravitational fields is explained by the equivalent mass that can be associated with every single quantum of energy (or electromagnetic nanowave) that originates radiation. From the Planck relation we deduce every quantum has an energy $E=hf$ and consequently, as per the Einstein relation $E=mc_o^2$, an equivalent mass $m=hf/c_o^2$.
If the equivalent mass in its motion of deflection doesn't undergo external resistant forces then we can affirm certainly the deflection of quantum radiations is independent of frequency: it is certainly true in a vacuum and for celestial bodies without atmosphere.
It is valid in general also for continuous electromagnetic radiations.

4.a.2 If elementary particle is massive, with a resting electrodynamic mass m', its behavior into the gravitational field is altogether similar to the behavior of an ordinary inertial mass, and therefore in the absence of external resistant forces, the particle takes on the speed

$$v(r) = \sqrt{\frac{2\,G\,M_o}{r_o}\,\frac{r_o - r}{r}} \qquad (16)$$

where r_o represents the initial point from which the massive particle falls into the gravitational field generated by M_o. In the absence of external resistant forces the particle fall is therefore independent of mass, if instead external resistant forces (like atmosphere) are present, then the particle motion and its speed v(r) depend on the electrodynamic mass of particle.
We know electrodynamic mass of charged particles changes with the speed and into the gravitational field it assumes the expression

$$m = m'\left(1 - \frac{v^2}{2c_o^2}\right) = m'\left(1 - \frac{GM_o}{c_o^2 r_o}\frac{r_o - r}{r}\right) \qquad (17)$$

We observe the electrodynamic mass of the moving particle into the gravitational field decreases when the distance r decreases and it becomes zero at the distance

$$r_R = \frac{r_o}{1 + \frac{2r_o}{R_s}} \qquad (18)$$

where $R_s=2GM_o/c_o^2$ is the Schwarzschild distance. Mass is negative for $r<r_R$ and consequently particle is unstable in this zone of the field (fig.7).

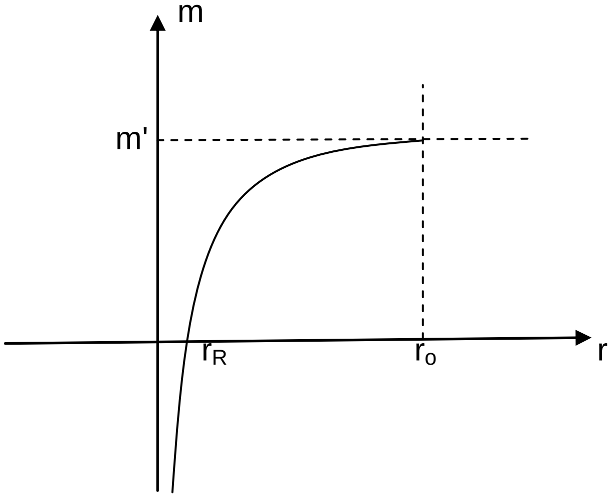

Fig.7 Trend of the electrodynamic mass of a moving elementary particle into the gravitational field.

We think a massive elementary particle in fall into a gravitational field would have to generate a smallest gravitational perturbation[1] like an ordinary body in fall. It needs also to specify this smallest gravitational perturbation has nothing to do with electromagnetic energy emitted in quantum shape by accelerated particle at the expense of electrodynamic mass of particle.

It is interesting to see now if the variable electrodynamic mass into the gravitational field influences the perturbation.

The space length λ_p, the duration T_p and the perturbation speed c_p have the same trend of ordinary masses and consequently are independent of particle mass; the perturbation energy $W_p(r)$ depends instead on the electrodynamic mass of particle. In that case in fact we have

$$W_p(r) = \frac{GM_o}{r_o}\frac{r_o - r}{r}\, m'\left(1 - \frac{v^2}{2c_o^2}\right) \qquad (19)$$

and calculating

$$W_p(r) = \frac{GM_o m'}{r_o}\,\frac{r_o c_o^2 - GM_o}{r_o c_o^2}\,\frac{r_o - r}{r} \qquad (20)$$

Considering the Schwarzschild distance

$$R_s = \frac{2GM_o}{c_o^2} \qquad (21)$$

the perturbation energy can be written also in the shape

$$W_p(r) = \frac{GM_o m'}{r_o} \frac{r_o - r}{r} \left(1 - \frac{R_s}{2r_o}\right) \qquad (22)$$

When the point of fall beginning of particle r_o coincides with the half of the Schwarzschild distance the energy of the gravitational perturbation is null. For $r_o<R_s/2$ the energy is negative and for $r_o>R_s/2$ the energy is positive (fig.8). Because the Schwarzschild distance is smallest it is possible to deduce that generally $r_o>R_s/2$.

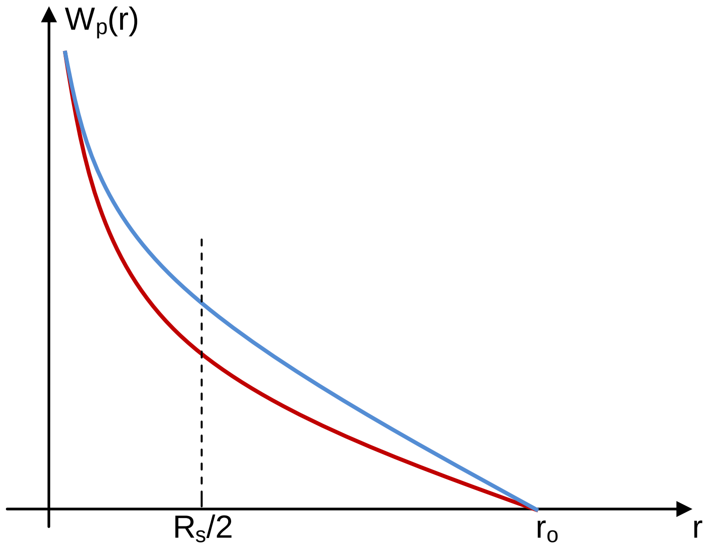

Fig.8 The blue graph represents the energy of the gravitational perturbation for an ordinary mass, the red graph represents the energy of the gravitational perturbation for a massive particle.

Note: ***Louis Rancourt has announced further results of his experiment on interactions between light and mass, that I sum up here:***
1. when the shaft of light passes horizontally over the trial mass placed into the earth's gravitational field, the mass wheight decreases.
2. when the shaft of light passes under the trial mass the mass weight increases.
The Rancourt effect is explicable in TR through a change of the gravitational field produced by the shaft of light: the field and wheight decrease because of a decrease of the gravitational constant G and increase because of an increase of the constant G: it shows the existence of an effect of light and energy quanta on both the gravitational field and the gravitational constant G.
Prospective effects of heating and cooling of mass have been considered and excluded.

Meantime Parviz Parvin has communicated always in ResearchGate his original and very interesting intuition on possible interactions among photons and between beams of photons. It allows to complete the symmetrical group of interactions Mass-Light-Mass (symmetry MLM or M^2L^2): 1. Interaction Mass-Mass (Newton law); 2. Interaction Mass-Light (Einstein second effect); 3. Interaction Light-Mass (Rancourt effect); 4. Interaction Light-Light (Parvin effect).

4.b The electrostatic field

The electrostatic field is a particular state of electromagnetic field that happens when all electric charges are constant and motionless. In that event the magnetic field is null and the electric field is static, for which an emission of electromagnetic energy there isn't.
The central system is defined by a constant positive electric charge +Q (pole) that generates an electrostatic field with central symmetry[2][6]. An elementary particle with charge -q undergoes an attractive force (according to the theory of the electrostatic field) given by the Coulomb law

$$F = \frac{Q\,q}{4\,\pi\,\varepsilon_o\,r^2} \qquad (23)$$

The motion law of elementary particle into the field is

$$m_o\,\frac{dv(t)}{dt} + Kv(t) = \frac{Q\,q}{4\,\pi\,\varepsilon_o\,r^2} \qquad (24)$$

where m_o=m' is the resting electrodynamic mass of particle.
Let's suppose that external resistant forces are null (k=0), we have

$$m_o\,\frac{dv(t)}{dt} = \frac{Q\,q}{4\,\pi\,\varepsilon_o\,r^2} \qquad (25)$$

Let's suppose still that at the initial instant t=0 the particle is placed at distance r_o from the central charge with null initial speed $v(0)=v(r_o)=0$. Solving[6] the (25) we obtain for every distance r the speed

$$v(r) = \sqrt{\frac{Q\,q}{2\,\pi\,\varepsilon_o\,m_o\,r_o}\,\frac{r_o - r}{r}} \qquad (26)$$

The (26) tell us an elementary particle into an electrostatic field has a behavior like into a gravitational field[1]. Now nevertheless we observe in the electrostatic field, also in the absence of external resistant forces (k=0), the particle's speed depends on the electrodynamic mass for which particles with different mass have different speeds, unlike what happens into the gravitational field.
Because then the relativistic electrodynamic mass of particle changes with the speed according to the relationship

$$m = m_o \left(1 - \frac{v^2}{2c_o^2}\right) \qquad (27)$$

we deduce

$$m = m_o \left(1 - \frac{Q\,q}{4\pi\varepsilon_o m_o r_o c_o^2} \, \frac{r_o - r}{r}\right) \qquad (28)$$

We observe besides at the critical distance

$$r_c = \frac{Qqr_o}{Qq + 4\pi\varepsilon_o m_o r_o c_o^2} \qquad (29)$$

electrodynamic mass becomes zero (m=0). For smaller distances the speed increases, the electrodynamic mass becomes negative and the particles becomes unstable. If the distance r_o is greatest, on the verge of infinite, we have (because Qq is negligible)

$$r_c = \frac{Qq}{4\pi\varepsilon_o m_o c_o^2} \qquad (30)$$

If the central charge is a proton and the secondary charge is an electron, both have electric charge equal to the electron: in that event we have $r_c=2{,}8\times10^{-15}$m, that coincides with the radius of the nucleus of hydrogen atom.
The distance r_c represents the critical distance because at that distance from the centre of central charge the particle's electrodynamic mass becomes zero; for greater distances electrodynamic mass is positive and for smaller distances is negative. At the critical distance the particle's speed equals the critical speed $v_c= \sqrt{2}\,c$. At smaller distances the particle's speed is greater than the critical speed.
It is manifest that a moving charged elementary particle into an electrostatic field is unable to generate a gravitational perturbation but the question is if it is able to generate another type of perturbation: the electrostatic perturbation.

5. Effects of electrostatic field

Let us consider now two physical situations concerning the motion of an electric charge -q into an electrostatic field with central symmetry in which the pole is represented by a constant charge +Q.

5a. Electrostatic perturbation

Like the fall of an ordinary mass or a massive particle into a gravitational field generates a gravitational perturbation, so also the motion of an electrical charge into an electrostatic field generates an electrostatic perturbation that propagates through space with space acceleration $a_r(r)$. This acceleration has physical dimensions of the frequency f_e and is given by

$$a_r(r) = f_e = -\frac{dv(r)}{dr} = \frac{1}{2r(r_o-r)}\sqrt{\frac{Qqr_o(r_o-r)}{2\pi\varepsilon_o m_o r}} \qquad (31)$$

Physical characteristics of electrostatic perturbation are similar to characteristics of gravitational perturbation

$$\begin{aligned} &\text{perturbation length } \lambda_e = r_o - r \\ &\text{perturbation duration } T_e = 1/a_r = 1/f_e \\ &\text{perturbation speed } c_e = \lambda_e/T_e = \lambda_e f_e \end{aligned} \qquad (32)$$

The speed of the front of electrostatic perturbation, for every r, is given by

$$c_e(r) = \frac{r_o}{2r} v(r) = \sqrt{\frac{Qq(r_o-r)}{2\pi\varepsilon_o m_o r_o r}} \qquad (33)$$

Electrostatic perturbation has the same graphic representation as gravitational perturbation (fig.9).

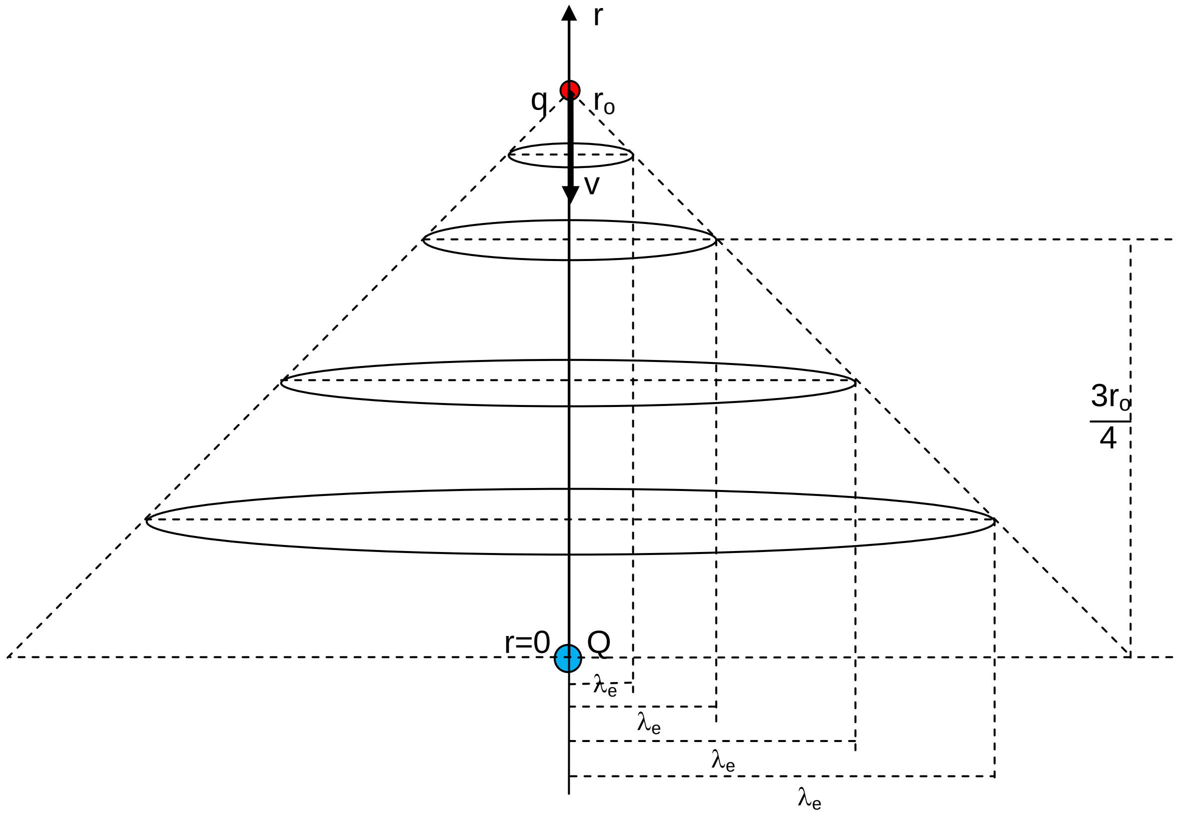

Fig.9 Graph of circular electrostatic perturbation for different values of r and different values of λ_e.

Besides electrostatic perturbation has an energy given by

$$W_e(r) = \frac{Qq(r_o-r)}{4\pi\varepsilon_o r_o r} \qquad (34)$$

Naturally it is valid whether for charged particles or for charged ordinary bodies.
Let us observe duration and speed depend on whether the two electric charges or the mass of moving charged particle, energy depends only on two charges while the length is independent of whether charges or mass. For gravitational perturbation instead duration and speed depend only on pole mass, energy depends on the two masses and length is independent of mass.

5b. Electromagnetic radiation

Electrostatic perturbation is due to the non-uniform motion of the charge q caused by the electrostatic field. We know an accelerated charged massive elementary particle in an electrostatic field represents a variable nanocurrent which generates an electromagnetic nanofield which is subject to the Maxwell equations[2][6] . Besides particle's electrodynamic mass decreases with the speed and simultaneously it emits quantum electromagnetic energy for precise values of speed. In particular the accelerated particle, at the physical speed c of light, has an electrodynamic mass equal to half of the resting electrodynamic mass and emits a first gamma quantum of electromagnetic energy; at the critical speed $v_c = \sqrt{2}\, c$ it emits a second gamma quantum with simultaneous zeroing of the electrodynamic mass. Both gamma quanta move with the physical speed of light.
The two effects of electrostatic field (electrostatic perturbation and electromagnetic emission) are independent of each other and both are due to the accelerated motion of the charged massive elementary particle into the electrostatic field: the perturbation is due to the accelerated motion into the electrostatic field, while the electromagnetic emission is due to the variation of electrodynamic mass with speed. Besides the two effects present a fundamental difference: in fact the electrostatic perturbation has continuous nature and it is generated for every value of the distance r, the electromagnetic radiation instead has quantum nature and it is emitted by particle only for a few characteristic discrete values of electrodynamic mass, speed and distance.

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