Relativity and Quantum Electrodynamics in the Theory of Reference Frames: the Origin of Physical Time

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Abstract

In this paper the main aspects of the Theory of Reference Frames are presented: in particular we consider the relativistic relation between time and mass, the electrodynamics of a moving charged particle, the quantum electrodynamic behavior of accelerated electron and a new explanation of the Compton effect.

1. Introduction

From my viewpoint the modern Relativity is represented by the Theory of Reference Frames[1]. This theory is based on the Principle of Relativity, in the same enunciation by A. Einstein and G. Galilei, and on the novel Principle of Reference that claims the existence of a preferred reference frame which coincides with the reference frame where the evolution of the considered physical phenomenon happens. It's advisable to clarify that the preferred reference frame in the Theory of Reference Frames is different from the ether which in classical physics was the absolute reference frame.

The Principle of Constancy of the Speed of Light isn't valid in the new theory and it is replaced with the definition of two speed of light: the physical speed and the relativistic speed[1][2]. The physical speed is constant (equal to ≈300000 km/s) and is the speed with respect to the reference frame where propagation of light happens, the relativistic speed on the contrary is variable and depends on the relative speed between the reference frame where propagation happens and the reference frame of the observer. In the Theory of Reference Frames Lorentz's space-time transformations aren't valid and a new group of transformations is proved in which an important physical property of time is pointed out.

In the new theory the connection between Relativity and Quantum Electrodynamics is represented by the concept of electrodynamic mass of a charged elementary particle[3]: the electrodynamic mass is different from the dynamic mass of mechanical systems. In fact the dynamic mass of a mechanical system is a virtual concept and increases with the speed; the electrodynamic mass of a particle on the contrary is a real physical concept and decreases with the speed. In the central field generated by nucleus, at the speed of light the electrodynamic mass of electron disappears completely and in its place two γ photons are produced. Like this it is possible to explain simply the production by one electron of a pair of γ photons that are quanta of energy[3]. In the last part of the paper a new theory of the Compton effect according to the Theory of Reference Frames is presented.

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2. Equations of space-time relativistic transformations with respect to reference frames with any relative velocity

2.1 Time and mass

The S[x,y,z,t,] reference frame is supposed at rest and the S'[x',y',z',t'] reference frame moves with respect to S with variable velocity **u.** The P material point is inside the S' moving reference frame, moves with **v'** velocity with respect to S' and with **v** velocity with respect to S (fig.1). In the considered physical situation S' is the preferred reference frame and its t' own time is the inertial time of the examined physical event.

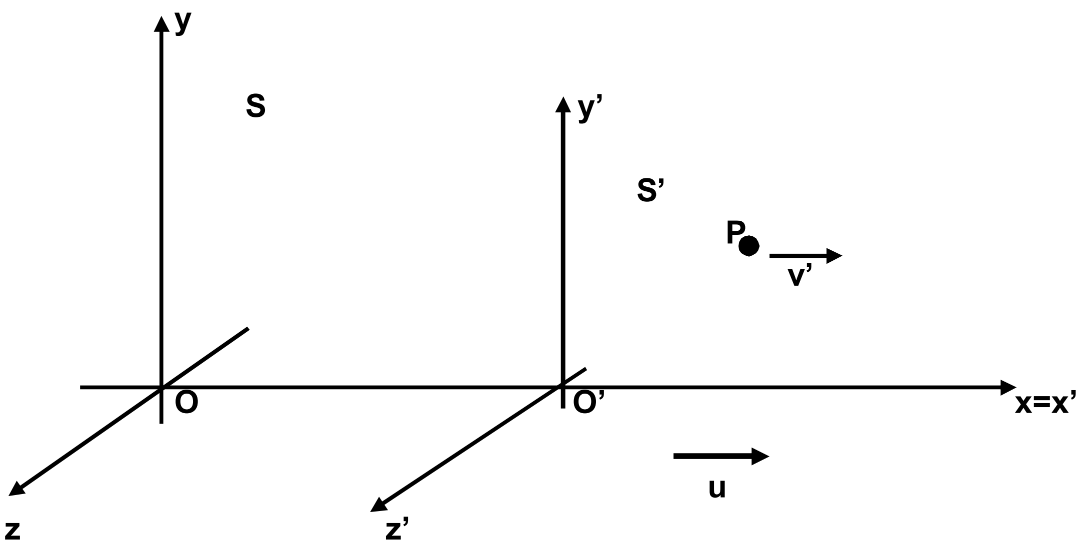

Fig.1 The S[x,y,z,t] reference frame is at rest and the S'[x',y',z',t'] reference frame is in motion with **u** variable velocity. The P point is inside the S' moving reference frame.

Supposing external resistant forces are null the law of motion of the P point is F'=m'dv'/dt' with respect to the S' reference frame and F=mdv/dt with respect to the S reference frame.
The m' mass of the material point is placed under the action of the F' force with respect to the S' reference frame and the m mass of the same material point is placed under the action of the F force with respect to the S reference frame.
The force F is obtained adding to the force F' the force

$$F_o = m \frac{du}{dt}$$

and as in the considered hypothesis F' and F_o have te same direction and verse we have

$$F = F' + F_o$$

$$F - F_o = F'$$

$$m\frac{dv}{dt} - m\frac{du}{dt} = m'\frac{dv'}{dt'}$$

As v=v'+u continuing the calculation[3] we have

$$\frac{dt}{dt'} = \frac{m}{m'} \qquad (1)$$

$$dt = \frac{m}{m'}dt' \qquad (2)$$

The previous relationships (1) and (2) are important because they link the time and the mass of the material point with respect to the two reference frames and establish that the physical time was born when the mass was born. From these two relations it arises that if the two masses in the two reference frames are not equal, the two considered reference frames aren't synchronous: in our situation the t' time of the S' reference frame, where the physical event happens (preferred reference frame according to the Principle of the Reference), is the inertial time while the t time of the S reference frame is the time of the observer in S. In the Theory of Reference Frames no twin paradox is possible: the t' time is the own real time of the physical event, the t time is the calculated time of laboratory.

2.2 General equations of space-time transformations

In concordance with both the fig.1 and what we have explained in the ref.s [1] and [3] we can write the following general equations of space-time transformations that are valid for all inertial and not inertial reference frames

$$\begin{aligned} x' &= x - \int_0^t u\,dt \\ y' &= y \\ z' &= z \\ dt' &= m'dt/m \end{aligned}$$

For complex systems (bodies) the mass is constant with the velocity and the general equations of space-time transformations become simpler

$$\begin{aligned} x' &= x - \int_0^t u\,dt \\ y' &= y \\ z' &= z \\ t' &= t \quad \text{(inertial time)} \end{aligned}$$

that are concordant with the equations of space-time transformations proved in the ref.[1]. If the two reference frames are inertial the u speed is constant and the equations of space-time transformations become

$$x' = x - ut$$
$$y' = y$$
$$z' = z$$
$$t' = t \quad \text{(inertial time)}$$

3. On the electrodynamics of a moving charged particle

The complex mechanical systems don't have electric charge and therefore they aren' t sensible to electromagnetic forces, the elementary particles on the contrary because of electric charge are sensible to electromagnetic forces and therefore they are electrodynamic systems. Moreover the mass of elementary particles, just because sensible to electromagnetic forces, is substantially different from the mass of mechanical systems sensible to mechanical forces. It is also well known that an accelerated charged elementary particle emits radiant energy that propagates with the speed of light; mechanical systems don' t produce this emission. For all these reasons we call "electrodynamic mass" the mass of elementary particles in order to distinguish it from the "mass" of mechanical systems.
Let us consider therefore a charged elementary particle with m_o electrodynamic mass at rest and null initial speed, accelerated by a constant F electric force. Under the action of the F force the particle acquires an increasing v speed and at the same time it emits a radiation that propagates with c speed. This radiation originates necessarily from the electrodynamic mass of the particle and therefore we have a transformation of electrodynamic elementary mass to radiant energy that propagates with the c speed of light. In consequence of this action the electrodynamic mass of the particle decreases while its speed increases.
In mechanical systems the applied force provides the mass with kinetic energy, in electrodynamic systems the applied force converts the electrodynamic mass into radiant energy. As the considered elementary particle has an intrinsic energy at rest $E_o=m_oc^2$, at the velocity v it has an intrinsic energy $E=mc^2$, and the difference in the intrinsic energy is equal to the kinetic energy of the equivalent mechanical system. Therefore we have (for the complete calculation see ref.[3])

$$E_o - E = \frac{1}{2} m_o v^2$$

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

$$m = m_o \left[1 - \frac{1}{2} \frac{v^2}{c^2} \right] \qquad (3)$$

and putting β=v/c

$$m = m_o \left(1 - \frac{1}{2}\beta^2\right) \qquad (4)$$

The previous (3) and (4) formulas represent the relativistic law of real variation of the electrodynamic mass of a charged elementary particle with the speed.
For v=0 we deduce the electrodynamic mass coincides with the m_o electrodynamic mass at rest and for v=c the electrodynamic mass becomes half and so at the speed of light half of the electrodynamic mass of particle transforms into radiant energy.
An accelerated elementary particle emits radiant energy at the expense of its electrodynamic mass and the decrease of the electrodynamic mass is a real physical effect. With this process the work executed by the applied force F on the charged particle gives to this a velocity and at the same time the particle's electrodynamic mass is transformed into radiant energy.

4. Quantum electrodynamics of electron

The radiant energy obtained by this process can be considered equivalent to a photon (quantum of energy) with energy $W=m_oc^2/2=hf$ and with frequency $f=m_oc^2/2h$.
With regard to electron we have the following features in frequency and in wavelength

$$f = 6{,}18\text{x}10^{19} \text{ Hertzs} \quad \text{and} \quad \lambda = 0{,}049 \text{ Angstroms}$$

that are typical magnitudes of the gamma radiation (γ radiation).
It's right to suppose that at the speed of light also the remaining half the electrodynamic mass is transformed into a second photon with equal energy.
In this way an accelerated elementary particle generates at the speed of light two photons (quanta of energy) that move with the speed of light and therefore from a particle with m_o electrodynamic mass at rest we obtain on the whole a radiant energy equal to the intrinsic energy of the elementary particle

$$W = \frac{1}{2} m_o c^2 + \frac{1}{2} m_o c^2 = m_o c^2$$

We observe moreover by (3) that the electrodynamic mass is null also when

$$1 - \frac{1}{2}\frac{v^2}{c^2} = 0$$

from which we obtain $v_c = c\sqrt{2} = 1{,}41$ c.
v_c is the critical velocity of the particle and it is greater than the velocity of light.

The electrodynamic mass of a particle becomes null by two different mechanisms:

a. production of two equal γ energy quanta (photons) that travel at the velocity of light
b. production of a "critical particle" (which is not a photon but a superparticle) when the particle achieves the critical velocity v_c = 1,41 c.

The quantity $W=m_oc^2$ represents all the potential energy that it is possible to obtain from the m_o electrodynamic mass at rest of an elementary particle and it is the "intrinsic energy" of the particle.
In this way in the Theory of Reference Frames we have justified completely by the concept of electrodynamic mass the phenomenon of production of couples of γ photons from a charged elementary particle and the transformation of electrodynamic mass into energy. Moreover we have proved that the process of transformation of electrodynamic mass into energy has a quantum nature.
We observe then that for velocities greater than the critical velocity the electrodynamic mass is negative and the charged elementary particle changes its physical nature becoming a superparticle.

5. Theory of the Compton effect

It is known that the Compton effect in the relativistic formulation isn't symmetric with respect to the wavelength and the frequency of incident photons. In fact the frequency shift depends on the frequency of incident photon ($f-f'=0{,}024ff'(1-\cos\theta)/c$) while the wavelength shift doesn't depend on the wavelength of incident photon[4] but only on the angle of scattered photon ($\lambda'-\lambda=0{,}024(1-\cos\theta)$). Moreover toward the incident photon ($\theta=0°$) whether the frequency shift or the wavelength shift are null.
Let's explain now the Compton effect in the Theory of Reference Frames and suppose that " hf " is the energy of the incident photon, " hf ' " is the energy of the scattered photon and $mv^2/2$ is the kinetic energy of the ejected electron (fig. 2).

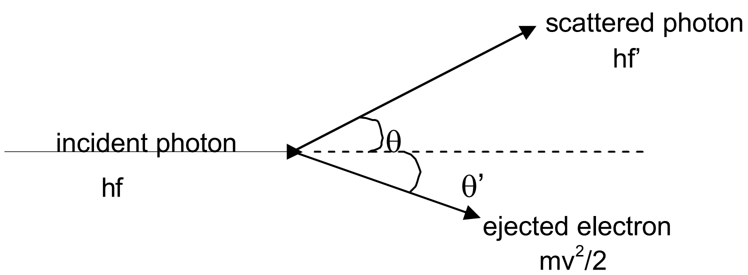

Fig.2 Graphic representation of the Compton effect.

For the principle of conservation of energy (5) and for the principle of conservation of momentum (6) we have

$$hf = hf' + mv^2/2 \qquad (5)$$

$$m^2v^2 = h^2f^2/c^2 + h^2f'^2/c^2 - 2h^2ff'\cos\theta/c^2 \qquad (6)$$

Calculating v^2 in (5) and replacing in (6) we have the Compton effect with respect to frequency

$$f - f' = \frac{h\,f\,f'}{mc^2}(1 - \cos\theta) + \frac{h\,(f - f')^2}{2mc^2} \qquad (7)$$

and the Compton effect with respect to wavelength

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta) + \frac{h\,(\lambda' - \lambda)^2}{2mc\lambda\lambda'} \qquad (8)$$

Whether in (7) or in (8) we remark the presence of a term of second order that is absent in the relativistic formulation where for $\theta=0°$ frequency shift and wavelength shift are null.
Specifically from (8) we deduce for $\theta=0°$

$$\lambda' - \lambda = \frac{2mc}{h}\lambda\lambda' \qquad (9)$$

The (9) proves that a small shift of wavelength is present also toward the incident photon ($\theta=0°$).
Let's calculate now the relationship between θ and θ' and to that end let's consider the momentum whether in the horizontal direction or in the perpendicular direction (fig.3).

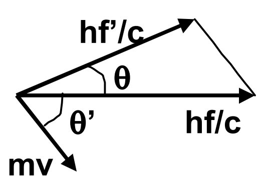

Fig.3 Graphic representation for the calculus of the relation between θ and θ'

We have in the horizontal direction

$$\frac{hf}{c} = \frac{hf'}{c}\cos\theta + mv\cos\theta' \qquad (10)$$

and in the perpendicular direction

$$0 = \frac{hf}{c}\,'\sin\theta - mv\sin\theta' \qquad (11)$$

From (10) and (11) we have

$$\frac{hf}{c}\,'\sin\theta = mv\sin\theta'$$

$$\frac{h}{c}(f - f\,'\cos\theta) = mv\cos\theta'$$

and

$$tg\theta' = \frac{f\,'\sin\theta}{f - f\,'\cos\theta} \qquad (12)$$

The (12) is concordant with Compton and Simon' s relativistic relationship and gives the following results:

a. for $\theta=0°$, $\theta'=0°$
b. for $\theta=90°$, $\theta'=\text{arctg}\, f'/f \approx 45°$
c. for $\theta=180°$, $\theta'=0°$

The classical theory of the Compton effect excludes the effect for $\theta=0°$ because whether frequency shift or wavelength shift are null but Compton and Simon's relationship foresees this effect ($\theta=0°$, $\theta'=0°$). The Theory of Reference Frames allows therefore to exceed this contradiction.

References

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