Research article

Photon: a first model that describes it.

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I am the author of the following textbooks:
1. "Verso la Fisica", published by Arianna Edizioni: text intended for the two-year period of the scientific high school, of which the link is the following link
https://www.amazon.it/s?k=verso+la+fisica&__mk_it_IT=ÅMÅŽÕÑ&ref=nb_sb_noss

2. "Con me stanno buoni", an book that presents a realistic presentation of today's school, going beyond the facade that hides it.
https://www.amazon.it/s?k=con+me+stanno+buoni+francesco+ferrara&__mk_it_IT=ÅMÅŽÕÑ&ref=nb_sb_noss

3. **Il danzatore cosmico**, Aracne edizioni, divulgation physics text
https://www.youtube.com/watch?v=gTgkX2K1RFE

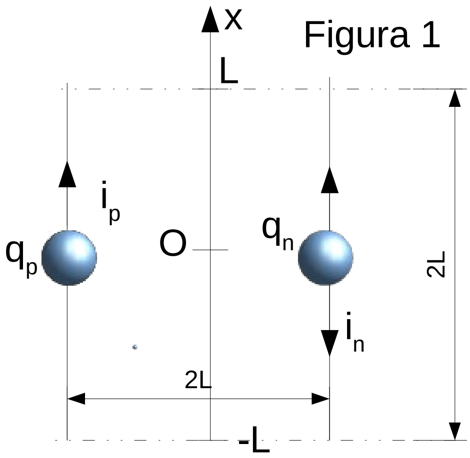
1. Introduction

My name is Francesco Ferrara, I am a physics teacher and an independent researcher.
I have always shown a lively involvement with knowledge, favouring a type of holistic approach: my interests range from physics to electronics to medicine to philosophy.
My research mainly makes use of unofficial sources, coming mainly from the network world, which tend to promote content other than officially accepted. I believe that the contribution that independent researchers have given to science, in the most disparate sectors, is noteworthy, since these scholars have been exclusively motivated by a healthy curiosity, devoid of economic interests.

1.1 Nomenclature

Physical dimension	Symbol	Unit of measure
Duration of the current pulse	τ	s
Maximum intensity of the current generated by the positive sphere	i_p	A
Maximum intensity of the current generated by the negative sphere	i_n	A
Period of the waveform of the current through a generic section	T	s
Length of the two strings of current	2L	m
Charge of the positive sphere	$q^+=q_P$	C
Charge of the negative sphere	$q^-=q_n$	C
	$q_p=1.60217733\cdot 10^{-19}\,C$ $q_n=-1.60217733\cdot 10^{-19}\,C$	
sphere speed positively charged	$v_p(t)$	m/s
sphere speed negatively charged	$v_n(t)$	m/s
Average speed, on a period, of the negatively charged sphere	v_{nm}	m/s
Average speed, on a period, of the positively charged sphere	v_{pm}	m/s
Angular pulsation of the two spheres	ω	s^{-1}

2. Presentation of model



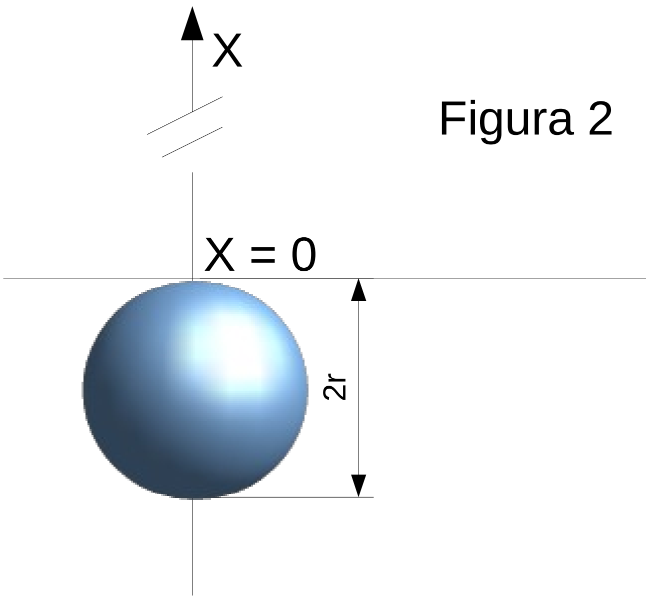
The model of photon, implemented by me is composed of two parallel, thread-like strings with a length equal to 2L,($L \simeq 7{,}424791147 \cdot 10^{-15} m$), the distance between the strings is, also, equal to 2L

Two spheres, without mass, one positively charged and one negatively charged, having both radius, equal to the classic radius of the electron ,move, with harmonic motion, at the speed of light. Each of the spheres describes a current string. The spheres, a positive and a negative one, go in the same direction. Since one of the two spheres is positive, while the other is negative, two currents are generated which have the opposite *direction The speed of the spheres has a sinusoidal waveform, it reaches a maximum value for x =0, on the contrary , is zero when x =L and x = -L*

We refer, now, to the section corresponding to x = 0. In this section the speed will be maximum and equal to that of the light c.

By indicating with τ, the time interval required for the charged sphere to pass through the abscissa section x = 0, it is possible to write:

$$\tau = \frac{2r}{c} \quad \text{Relation 1}$$

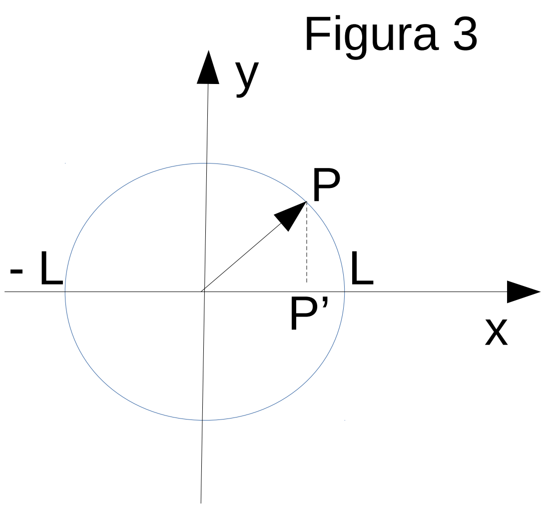


We calculate the current that passes through the section having abscissa x = 0, we have:

$$i_p = \frac{\Delta q}{\Delta t} = \frac{e\,c}{2r} \quad \text{Relation 2}$$

In the section having abscissa x = 0, in a certain instant, which we call instant zero, there is a current pulse, whose intensity is equal to "ec / 2r" and whose duration is equal to "2r / c".
Whit the symbol "T" we denote the period, i.e. the time required for the charged sphere , to complete a complete oscillation,

After a time equal to half the period, the sphere will pass again through the abscissa section x = 0, proceeding downwards, a current pulse of equal amplitude will be generated, ie "ec / 2r", but negative.
To calculate the duration of a period, i.e. the time taken by the ball to make a complete oscillation, it is possible to consider the harmonic motion of the sphere, along the string, such as the projection, along a diameter, of a point that moves with circular motion and uniform along a circumference of radius L, at a speed equal to that of light.



Consider a graph showing the trend, over time, of the current, corresponding to the abscissa section x = 0.
By indicating with x the abscissa of point P ', see figure 3, it is possible to write:

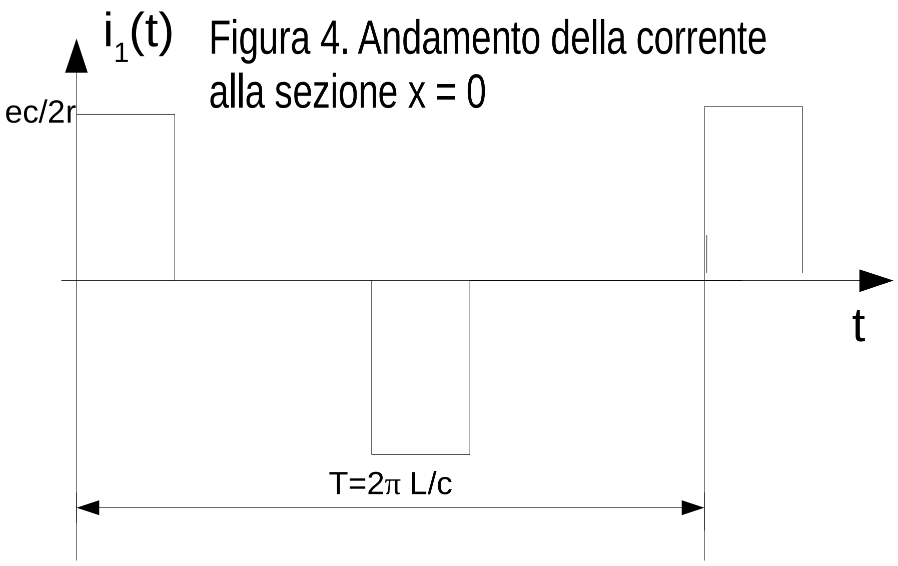
$$x(t) = L \cdot \cos \omega t \quad \text{Relation 3}$$

Deriving with respect to time, the relation 3 has:

$$v_p = -\omega L \, sen\, \omega t \quad \text{Relation 5}$$

The quantity ωL is equal to the tangential speed at point P, which in our case is equal to the speed of light.

Si ha:



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$\omega L = c$ Relation 6

we have:

$\frac{2\cdot\pi}{T} L = c$ Relation 7

$T = \frac{2\cdot\pi\cdot L}{c}$ Relation 8

Considering the string described by the negatively charged ball, there will be an expression of the current, i_2 (t), equal to i_1 (t), but inverted in sign.

As already mentioned, the current is maximum in the corresponding section at x = 0, its intensity decreases when from section x = 0, we move to the other sections of the string, until it reaches zero, when x = L and x = -L

In the expression of the current it is necessary to take into account a factor that modulates the amplitude of the current itself, when we move from the section x = 0, to the other sections of the string.

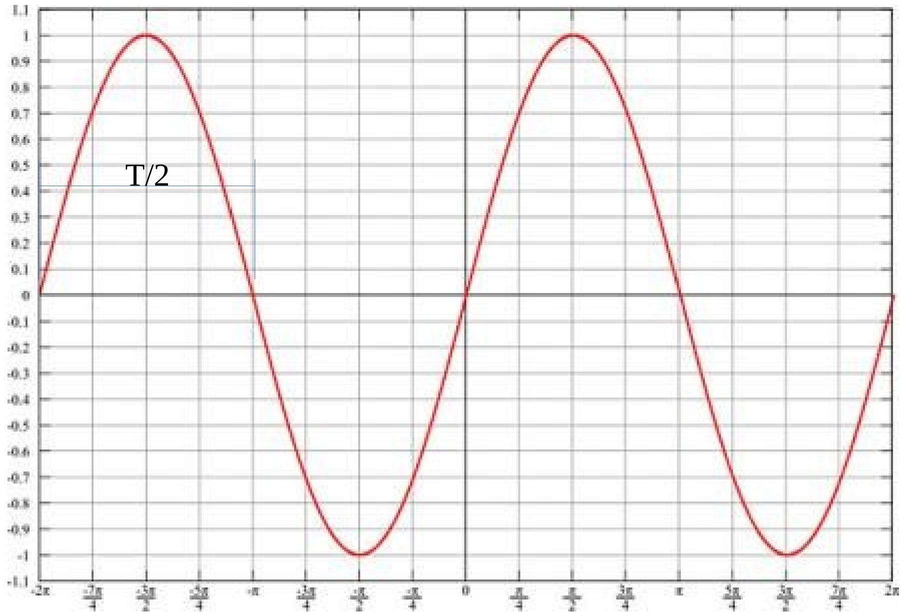
This factor is:

$\cos \frac{\pi}{2L} \cdot x$ Relation 9

For x = 0, we have cos (0) = 1, the current intensity will be maximum. When x = + L or x = -L we will have: cos (π / 2) = 0, or cos (-π / 2) = 0

Let's now calculate the average speed maintained by the charged sphere, during a complete cycle along the string.

We impose that:



$$\int_0^{T/2} c \cdot sen(\omega \cdot t)\, dt = \frac{V_{pm} \cdot T}{2} \quad \rightarrow$$

$$\frac{-c}{\omega}\left(\cos\left(\frac{2\cdot\pi}{T}\cdot\frac{T}{2}\right)-\cos(0)\right)=\frac{2\cdot c}{\omega}=\frac{v_{pm}T}{2} \quad \rightarrow \quad \frac{cT}{\pi}=\frac{v_{pm}T}{2} \quad \rightarrow \quad v_{pm}=\frac{2c}{\pi}$$

If we consider a generic section x, the waveform of the current will be moved forward with respect to that relating to the section x = 0, by a quantity, approximately, equal to πx / 2c. Is possible to write an expression of current as the abscissa x changes and as a function of time t. We could write:

$$i_p(t)=\frac{ec}{2r}\cdot\cos\left(\frac{\pi}{2L}x\right)\sum_{n=0}^{\infty}(-1^n)u\left(t-n\frac{T}{2}-\frac{\pi x}{2c}\right) \quad \text{Relation 10}$$

The abscissa x intervenes on two parameters of the waveform: the amplitude and the phase. The relationship 10 is approximate, since the term that takes into account the phase shift of the waveform of the current, in a generic section x, with respect to the section x = 0, was obtained as the ratio between the abscissa itself and the speed average of the charged sphere.
The current of the negative sphere will be practically identical but changed in sign

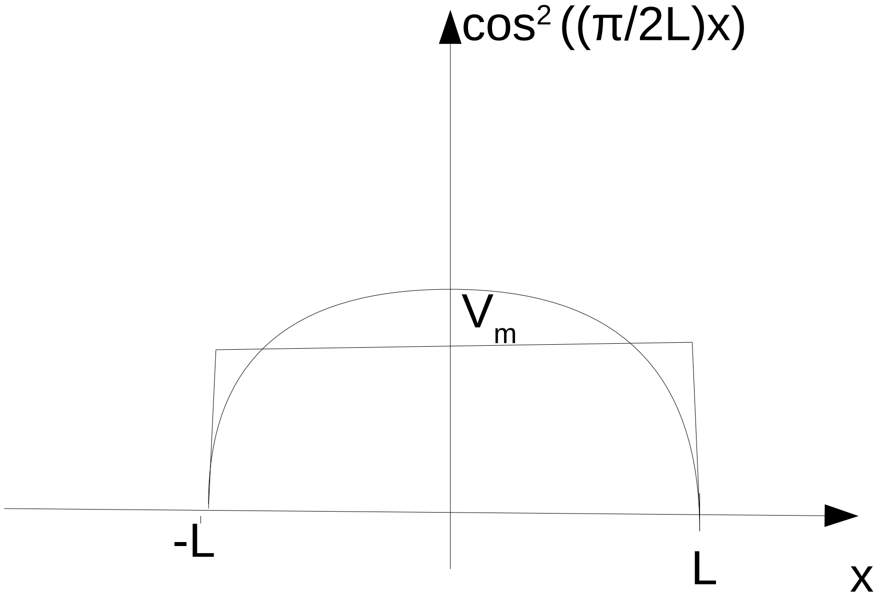
$$i_n(t)=\frac{-ec}{2r}\cdot\cos\left(\frac{\pi}{2L}x\right)\sum_{n=0}^{\infty}(-1^n)u\left(t-n\frac{T}{2}-\frac{\pi x}{2c}\right) \quad \text{Relation 11}$$

We now propose ourself, to calculate the energy lavished by this system in a range time T, equal to the period.
Assuming that the two strings of current are in the vacuum, we lift the current to square and we multiply by the characteristic impedance of the vacuum Z0, so obtaining the power. By multiplying the power, for the duration of a period, it is possible to calculate the energy lavished by the system consisting of the two current strings, in a period.
We can write:

$$E_{periodo} = \frac{e^2 \cdot c^2}{4 r^2} \cdot \cos^2\left(\frac{\pi}{2L} x\right) \cdot Z_0 \cdot T \quad \text{Relation 12}$$

The term $\cos^2\left(\frac{\pi}{2L} x\right)$,which is a pure number, as the abscissa changes, modulates the height of the current pulse, for each section.

The term $\cos^2\left(\frac{\pi}{2L} x\right)$ will have an average value, along the 2L size of the string, which we can calculate:



To

calculate the average value of the term $\cos^2\left(\frac{\pi}{2L} x\right)$ we impose that:

$$V_m \cdot 2L = \int_{-L}^{L} \cos^2\left(\frac{\pi}{2L} x\right) dx = \frac{2L}{\pi} \int_{\frac{-\pi}{2}}^{\frac{\pi}{2}} \cos^2(y)\, dy = \frac{2L}{\pi}\left[\frac{\frac{\pi}{2}}{2} - \left(\frac{-\frac{\pi}{2}}{2}\right)\right] = \frac{2L}{\pi}\left[\frac{\pi}{4} + \frac{\pi}{4}\right] = \frac{2L}{\pi}\left[\frac{\pi}{2}\right] = L$$

We have:

$$V_m \cdot 2L = L \quad \rightarrow \quad v_m = \frac{1}{2}$$

In light of this result, it is possible to write that the average energy, in an entire period T, considering the entire length of the string of current , will be equal to:

$$E_{media\,.\,periodo} = \frac{e^2 \cdot c^2}{8 r^2} \cdot Z_0 \cdot T \quad \text{Relation 13}$$

The average energy in a period, of the string formed by the negatively charged sphere, will have the same expression.

Therefore, we have:

$$E_{Media.Totale} = \frac{e^2 c^2}{4 r^2} Z_0 T \quad \text{Relation 14}$$

It is possible to express T with the following relationship: $T = \frac{2\pi L}{c}$ Relation 15

Replacing the 15 in the 14 we have:

$$E_{Media.Totale} = \frac{e^2 c^2}{4 r^2} Z_0 \frac{2\pi L}{c} \quad \rightarrow \quad E_{Media.Totale} = \frac{e^2 c Z_0 \pi L}{2 r^2} = \frac{e^2 Z_0 \pi L}{2 r^2} \cdot c = \frac{e^2 Z_0 \pi L}{2 r^2} \cdot \omega L = \frac{e^2 Z_0 \pi L^2}{2 r^2} \cdot \omega$$

$$E_{Media.Totale} = \frac{e^2 Z_0 \pi L^2}{2 r^2} \cdot \omega \quad \text{Relation16}$$

The relationship obtained is very significant, since it testifies that the object implemented by us behaves, in fact like a photon, having available, at each period, an amount of energy equal to the product of a constant, for the angular pulsation ω.
It is known, from Planck's relation, that the energy of a photon can be expressed as product of the reduced Planck constant, for the pulsation ω, we have:

$$E = \hbar \cdot \omega \quad \text{Relation 17}$$

By equating member to member relations 16 and 17 we have:

$$\frac{e^2 Z_0 \pi L^2}{2 r^2} = \hbar \quad \rightarrow \quad \frac{L^2}{r^2} = \frac{2\hbar}{e^2 Z_0 \pi} \quad \rightarrow$$

$$\frac{L}{r} = \sqrt{\frac{2\hbar}{e^2 Z_0 \pi}} = \sqrt{\frac{2 \cdot 1.05457266 \cdot 10^{-34}}{(1.60217733 \cdot 10^{-19})^2 \cdot 376.730313461 \cdot \pi}} \simeq 2{,}63482909$$

Since the sphere with positive charge has a radius equal to the classical radius for the electron, we have:

$$L = r \cdot 2{,}63482909 \simeq 2{,}817940326727 \cdot 10^{-15} \cdot 2{,}63482909 \simeq 7{,}424791147 \cdot 10^{-15}\, m$$

The model describes, to all intents and purposes, the behaviour of a photon: the currents along the two strings, proceeding in the opposite directions, generate two masses of an electromagnetic nature, equal and opposite, this will make null the total mass of the photon . The energy transported at each period will be exactly that expressed by Planck's well-known formula.
The photon is a well-defined physical object, therefore, it makes sense to speak of polarization. The direction of polarization is precisely that imposed by the direction in which the charged spheres oscillate, determining the strings of current . Classical physics, on the other hand, attributed to the photon the same polarization of the electric field of the electromagnetic wave responsible for the presence of the same photons. It makes no sense to speak of polarization of an undefined energy package.