DESCRIPTIVE MATHEMATICAL MODEL FOR THE GENERATION OF PARTICLES AND ANTIPARTICLES IN A VACUUM: THE CASE OF THE ELECTRON AND THE POSITRON

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ABSTRACT

The electron-positron pair (rotating charged antiparticle particle) is created at high energies and only under precise conditions. This article aims to identify a mathematical model that hypothesizes the functional algebraic macro-mechanism with which the presence of an electric dipole endowed with mass is perceived from the vacuum without the need for an inelastic collision[1] as in the case of pair productions.

INTRODUCTION

The passage of electromagnetic energy excites the electric charges present in the vacuum. Our mathematical model predicts the situation (the ultimate equilibrium) in which, thanks to the accumulation in small volumes (energy bubbles)[2] of electrical charges of opposite sign interacting with each other, an electron-positron pair materializes [Fig.1b].

METHODS

The mathematical model is schematized with a macro-interaction between pairs of still virtual fermions m_{e^+} and m_{e^-} which, characterized by: electric charge e+ and e-; by the respective magnetic dipoles; each with spin s=1/2h, will tend to oscillate due to the action of the electromagnetic wave. In particular, the electric component gives energy to the radially reacting particles, while the magnetic component, orthogonal to the electric one, acts on both magnetic dipoles of the virtual particles tending to separate them along the spin axis. In this situation of "the ultimate equilibrium" the particles are materializing thanks to the reduction of the volume [Fig.3] due to the conservation of the spin. This separation will be counteracted by the pull of the electric force between the oppositely charged particles and the pull of the magnetic force between their respective magnetic dipoles. The macro interaction is represented with a spring and the reference model is an oscillator with two equal masses and three springs[3] with the same elastic constant $k_{v.el.}$(*"K of a vacuum"*) [Fig.1a]

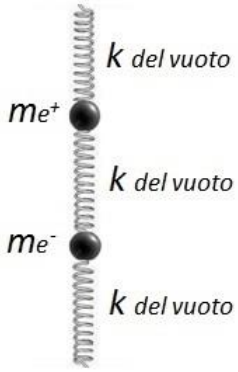

Fig.1a

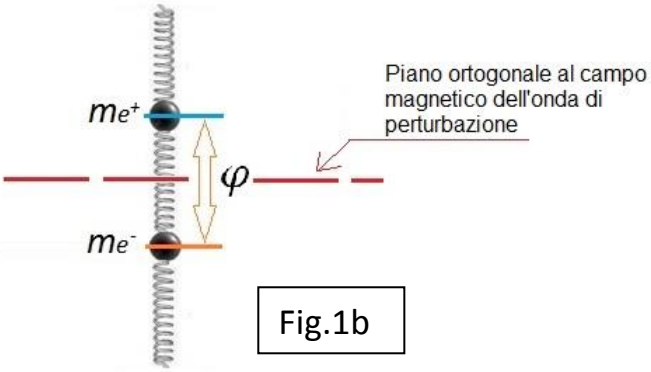

Fig.1b

$$\omega_0 = \sqrt{\frac{k_{v.el.}}{m_e}} \qquad k_{v.el.} = \frac{F_{el.}}{\varphi}$$

$$F_{el.\ (elastic)} = F_{electric\ between\ m_{e^+}\ \text{and}\ m_{e^-}}$$

$$If \quad F_{elastic} = F_{\ electric} = K_0 \frac{Q_e^+ * Q_e^-}{\varphi^2} \quad \text{then} \quad k_{v.el.} = \frac{K_0 * Q_e^2}{\varphi^3} \quad \text{and}$$

$$\omega_0^2 = \frac{K_0 * Q_e^2}{\varphi^3 * m_e} \quad then \quad \varphi = \sqrt[3]{\frac{K_0 * Q_e^2}{\omega_0^2 * m_e}}$$ which we will call Equation of the ultimate equilibrium **(i)**

ω_0 = "natural" frequency of oscillation of the dipole (virtual or real)

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[1] Schwinger, Julian (1951-06-01). "On Gauge Invariance and Vacuum Polarization". *Physical Review*. American Physical Society (APS) AND *Brezin, E.; Itzykson, C. (1970-10-01). "Pair Production in Vacuum by an Alternating Field". Physical Review D. American Physical Society (APS) AND G. Breit; John A. Wheeler (1934-12-15). "Collision of two quanta of light".*

[2] Calvetti M. 2008 "Accelerated antiparticles" asimmetrie.it INFN

[3] Dal Fovo Franco 2018, "Cuopled oscillators and chaos"

In line with the oscillator model, we have represented the charged virtual particles as points (black balls) m_{e^+} and m_{e^-} . These "potential charged masses" before reaching the conditions of ultimate equilibrium are to be considered "diffused in a not-deterministic way" therefore not yet detectable as charged mass and are confined within the ellipsoidal regions schematized in figure 2. These regions of space, and their content in electric charges, as a consequence of the ultimate equilibrium equation (i) are to be considered in dimensional contraction as the frequency of the perturbation wave increases.

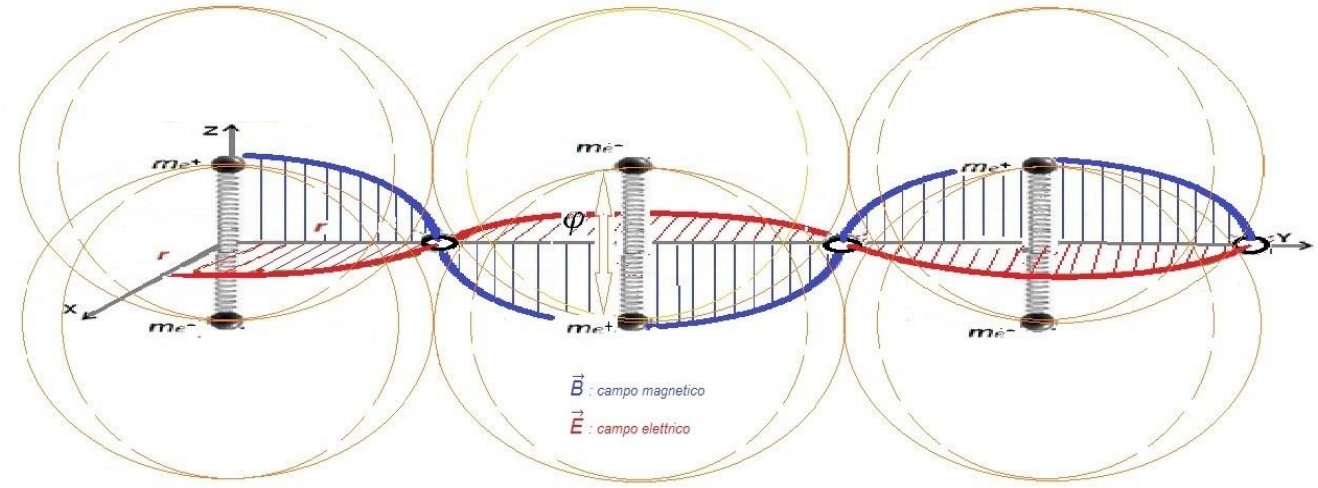


Fig. 2

RESULTS

This simple mathematical model finds an important theoretical confirmation when it is imposed that "φ" and "r" have the same value. By doing so we get the frequency we called ω_0^* (ultimate equilibrium equation). At this frequency of the electromagnetic wave disturbing the empty space, the value **r = φ** coincides with the known value of the radius of the electron (and of the positron). At this frequency ω_0^* a real electron-positron dipole will be perceivable, which translates into the creation of a matter-antimatter pair with mass generated by charge densification, or better by the "densification of large quantities of energy in a small volume".

If φ < r we could talk about VIRTUAL DIPOLE; when φ > r of REAL DIPOLE (with creation of electron and positron) ; when φ =r we will talk about DIPOLE in THE ULTIMATE EQUILIBRIUM;

Ultimate equilibrium ellipsoid equation **:** $\frac{x^2}{A^2} + \frac{y^2}{B^2} + \frac{z^2}{C^2} = 1$ in which

$$\begin{cases} A = B = \dfrac{v}{\omega_0} \\ C = \sqrt[3]{\dfrac{K_0 * Q_e^2}{\omega_0^2 * m_e}} \end{cases}$$

When v = c e $r = A = B = \frac{c}{\omega_0}$; $\varphi = C$ and, imposing r = φ, => $\omega_0^* = \frac{m_e * c^3}{K_0 * Q_e^2}$ (ii)

Natural frequency of oscillation of the real dipole or "ULTIMATE EQUILIBRIUM FREQUENCY"	ω_0^* =	1,0638E+23	1/s
Electron mass = Positron mass (antiparticle)	m_e =	9,1094E-31	Kg
Light speed	c =	2,9979E+08	m/s
Coulomb's electrostatic constant	K_0 =	8,9876E+09	N* (m^2 / C^2)
Charge of the electron	Q_e =	-1,6022E-19	C

Replacing ω_0^* in the expressions we get "r" and " φ "
in particular we get just the
VALUE OF RADIUS OF THE
SPHERE OF THE
ELECTRON

$r = c / \omega_0^* =$ 2,8180E-15

$\varphi =$ 2,8180E-15

	ω_0 [1/s]	r [metri]	φ [metri]	LOG(r)	LOG(φ)
1	1,0638E+01	2,8181E+07	1,3080E+00	7,45	0,12
2	1,0638E+03	2,8181E+05	6,0714E-02	5,45	-1,22
3	1,0638E+05	2,8181E+03	2,8181E-03	3,45	-2,55
4	1,0638E+07	2,8181E+01	1,3080E-04	1,45	-3,88
5	1,0638E+09	2,8181E-01	6,0714E-06	-0,55	-5,22
6	1,0638E+11	2,8181E-03	2,8181E-07	-2,55	-6,55
7	1,0638E+13	2,8181E-05	1,3080E-08	-4,55	-7,88
8	1,0638E+15	2,8181E-07	6,0714E-10	-6,55	-9,22
9	1,0638E+17	2,8181E-09	2,8181E-11	-8,55	-10,55
10	1,0638E+19	2,8181E-11	1,3080E-12	-10,55	-11,88
11	1,0638E+21	2,8181E-13	6,0714E-14	-12,55	-13,22
12	1,0638E+23	2,8181E-15	2,8181E-15	-14,55	-14,55
13	1,0638E+25	2,8181E-17	1,3080E-16	-16,55	-15,88
14	1,0638E+27	2,8181E-19	6,0714E-18	-18,55	-17,22
15	1,0638E+29	2,8181E-21	2,8181E-19	-20,55	-18,55
16	1,0638E+31	2,8181E-23	1,3080E-20	-22,55	-19,88
17	1,0638E+33	2,8181E-25	6,0714E-22	-24,55	-21,22
18	1,0638E+35	2,8181E-27	2,8181E-23	-26,55	-22,55

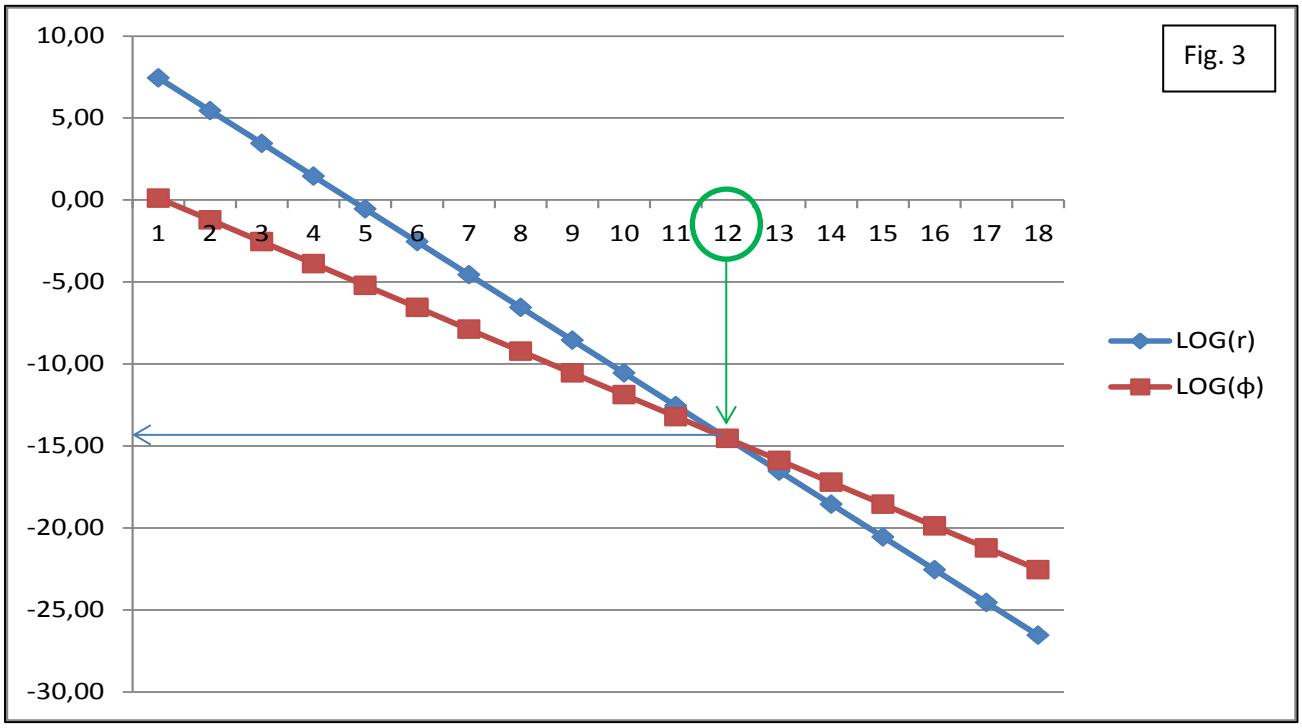
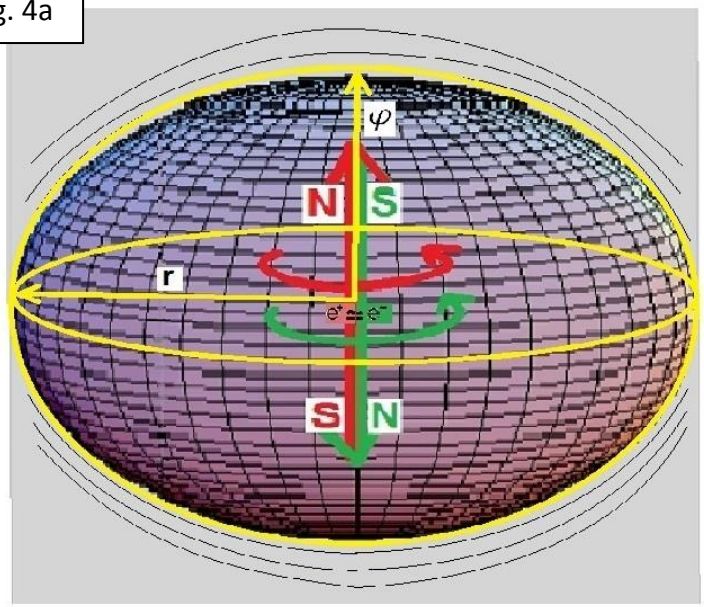


Fig. 3

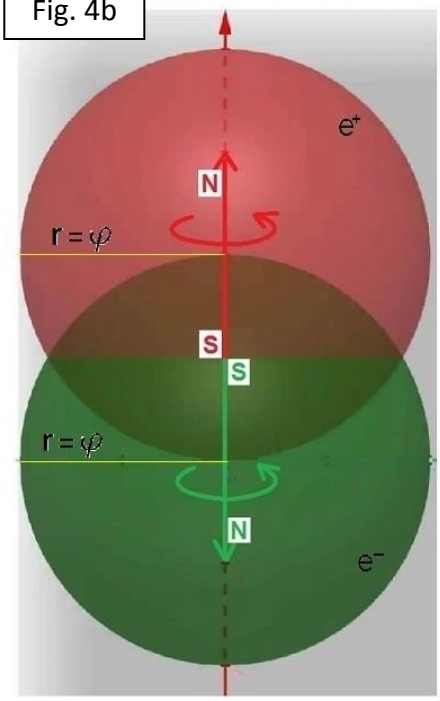
For pulsation values higher than those of ω_0^* , concerning E=1,022MeV, the graph no longer refers to the real case because beyond that threshold we no longer have two virtual particles linked, but two real ones that separate. Their separation, starting from the initial complete overlap, takes place at the last equilibrium distance, which occurs when the magnetic dipoles of the particles have forcibly translated until they have two overlapping coincident magnetic poles. Up to an infinitesimal earlier, the action between the magnetic dipoles of the particles recalls the starting position and favors the restoration of the initial configuration of superposition of electric charge. An infinitesimal beyond the last equilibrium distance, the action between the magnetic dipoles becomes repulsive and separates the two fermions, which at this point are real [Fig.4b].

Fig. 4a



Configurazione di equilibrio momentaneo delle particelle virtuali o situazione nel vuoto in mancanza di onde di perturbazione ossia in assenza di oscillazioni (situazione solo ipotetica per via della presenza della radiazione di fondo) [$e^- \simeq e^+$]

Fig. 4b



Configurazione di "ULTIMO EQUILIBRIO" al momento della generazione e della separazione dell'elettrone [e^-] dal positrone [e^+]

CONCLUSIONS

From the formula of the last equilibrium frequency we can calculate the link between the rest mass of the electron and the frequency of the electromagnetic wave that generated it [$E^* as\ a\ function\ of\ \omega_0^*$]:

$$\omega_0^* = \frac{m_e * c^3}{K_0 * Q_e^2} \text{ (ii) } \Rightarrow \omega_0^* = \frac{(m_e * c^2) * c}{K_0 * Q_e^2} \Rightarrow \omega_0^* = \frac{E^* * c}{K_0 * Q_e^2} \Rightarrow \boxed{E^* = \frac{K_0 * Q_e^2}{c} * \omega_0^* \text{ (iii) } = 0{,}511 \text{ MeV}}$$

In particular, for the electron/positron it is calculated exactly the well-known experimental value of 0.511MeV. This suggests that to obtain experimental confirmation of the creation of an electron and a positron from electromagnetic waves, it would be necessary to collide two waves with a frequency of the ultimate equilibrium perfectly aligned and polarized but with opposite directions so that all the energy transported transforms into mass (1 electron + 1 positron)[4].

Examples of these experiments are underway at the Relativistic Heavy Ion Collider (Rhic) at Brookhaven National Laboratory, in the United States[5] or also at the National Graphene Institute in the United Kingdom, at the University of Manchester, where they are observed the Schwinger effect in a device based on graphene superlattices[6]. The mathematical model described can be of support to this type of experimentations.

The aforementioned equations can describe in a simplified way a sort of "wave collapse" with which among all the possible configurations, or better, among all the modes of oscillation that are produced by the dynamic interaction of the two virtual particles, only in the situation of ultimate equilibrium the particles find the suitable configuration to manifest themselves materially at a precise situation in the space.

[4] Spadaro T. 2015 "Create matter. Production of matter thanks to special relativity." asimmetrie.it INFN

[5] Adam *et al.* (STAR Collaboration) (2021-07-27)"Measurement of e^+e^+ Momentum and Angular Distributions from Linearly Polarized Photon Collisions", di J. - *Physical Review Letters*

[6] Isabelle Dumé (2022-03-25) "Schwinger effect seen in graphene" –Physicsworld