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Structural Foundation and Geometry of the Material Singularity (and Its Quantum Entanglement)

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Abstract

In this paper we develop and study, as the second part of one more general development, the energy transmutation equation for the material singularity, previously obtained through the symmetrisation of a wave packet, that is, we develop the correlation between the terms of this equation, which accounts for the formation of matter from a previous vibrational state, and the different possible energy species. These energetic species are ascribed, in a simplified form, to the equation $\bar{E}_\omega = \bar{E}_k + \bar{E}_f$, which allows us, through its associated phase factor, to gain an insight into the wave character of the kinetic energy and thus to attain the basis of the matter-wave, and all sorts of related phenomenologies, including that concerning quantum entanglement. The formation of the matter was previously identified as an energetic process, analogous to the kinetic one, in which finally the inertial mass is consolidated as a mass in a different phase, now, in addition, the mass of the material singularity is identified as a volumetric density of waves of toroidal geometry created in the process of singularisation or energy transfer between species, which makes it possible to establish the real relation or correspondence between the corpuscular and photonic energy equation ($E = mc^2 = h\nu$), *i.e.* to explain through m the intimate sense of the first equivalence, which explains what ν is in the second one.

Keywords

Standard Model, Wave-Packet, Material Singularity, Wave-Particle Dualism, Wave Symmetrisation, Matter-Wave, Energetic Transmutation, Quantum Entanglement

1. Introduction

In this work, we will study and develop the theoretical approach presented previously [1]. There (in a first treatment or block), by means of a process of symmetrisation of wave packets and the resulting symmetrised wave packet (SWP), we established Equation (32) of [1] which, despite its fundamental character, we did not have the opportunity to deal with, mainly because that equation contained a *phase factor* and a condition for this factor with a simpler and more immediate treatment and consequences. Consequences such as the one expressed in Equation (39) of [1], which was the only one fully developed (second block of [1], from Sect. 5), having to leave the rest of the implications (for reasons of space, expository strategy and moderation) for another occasion, just as we had to leave aside those of Equation (32) mentioned before, and which we are now going to deal with in detail.

Equation (32), which we will obtain here without detailing the process, is an energy transmutation equation (ETE) consisting of three terms, which correspond to the three recognisable or differentiated forms of energy, among which we should highlight the kinetic, which consequently has a massive coefficient. The importance of this fundamental equation is that, in effect, we have an expression that relates in a natural way (through the process of symmetrisation) all these forms of energies but encoded in wave terms (as is the mass itself in it), which provides particular information, and additional to that that we can notice or find in a corpuscular treatment.

A first approach to the equation aims to identify and signify this additional information, highlighting the most immediate facts derived from a brief comparison with the corpuscular scheme.

It is on a second reading, the equation itself and, in particular, the mass coefficient (the mass) and the purely wave factor (phase factor), provide us with a huge amount of information. So much information we have had to derive from the main treatment of several differentiated epigraphs to reflect all that it suggests with respect to the most genuine questions of physics, which we have even had to elude because it exceeds the purpose of this work or gives rise to a new purpose as strong as the starting one.

Notwithstanding the latter, we will be able to say quite a lot about the mass and about the matter wave, and how it (the phase factor) explains quantum entanglement and naturally solves the EPR paradox [2]. Also the speed of light and the light itself, are associated in a conceptually wrong way with the energy at rest which is then associated with a frequency, whose origin is not known because the origin or the basis of the equivalence $E = mc^2 = h\nu$ is not known. We will be able to say this of that equivalence and why, under that foundation, the mass is energetically displayed in the form c^2. Going further, we will say why the mass is displayed in a two-dimensional form of light (which connects clearly with the two wave formants of the SWP) and why, instead, the formed object is three-dimensional. A question that, on the other hand, leads us directly to the link between the creation of mass (transformation of these formants) and the creation of the space in which it is located, of which we can tell its shape and size, and how or why it changes for the different families of particles, and for them themselves (fermions).

This, refers to the first term of Equation (32), regarding the other two, that of the mass formed (the massive coefficient treated above is that which accompanies the kinetic energy as a factor) and that of the electromagnetic energy brought into play, we will deal, in addition to their individualised study, with the correspondence or the progression of the processes in which they are involved. That is to say, we will address the real possibility of an inherent energy transfer between these terms, accounting for the increasing and cumulative evolution of the energy function in one and the decreasing and dissipative evolution in the other, and the consequent correlation, in these processes.

This long list of objectives may seem pretentious, but it is not. It is simply a list of everything that the equations give us, and what follows immediately from these first results: when the mass is not just m but a set of geometrical, wave, and dynamical variables, it is neither difficult nor excessive nor strange, but rather of unparalleled simplicity and unquestionable argumentative weight. As we consider it to have [1], and which we use as a basis here.

Indeed, the development carried out there allowed us to determine that all material things in this universe (fermions) start from an SWP, by being able to establish analytically as proof from that premise, as was done [1], a phasic structure in the standard model (SM) itself and a clear hierarchy between its particles. A confirmatory proof that will undoubtedly allow us to enjoy certain credit regarding what starts from the same framework, which is nothing but the SWP as the foundation of all physical relationships of the matter.

A framework of which, given its importance, the need to refer more directly to equations and concepts, and the non-existence of a corpus, we will carry out a quick review, incorporating the new elements, while giving a more general, compact theoretical treatment, and one free of the elements of the construction process developed in [1], which for these effects can be considered an annex.

2. Overview of the Energy Transmutation Equation (ETE)

We can form wave packets by superposition of plane waves of different shapes, such as the four presented in Equation (1):

$$\begin{aligned} &\Psi_{-}^{+}(x,t)=\int_{-\infty}^{+\infty}\mathrm{e}^{i(\omega_k t-kx)}\mathrm{d}k, \quad \text{and} \quad \Psi_{+}^{-}(x,t)=\int_{-\infty}^{+\infty}\mathrm{e}^{-i(\omega_k t-kx)}\mathrm{d}k, \quad \text{(a)} \\ &\Psi_{-}^{-}(x,t)=\int_{+\infty}^{-\infty}\mathrm{e}^{-i(\omega_k t-kx)}\mathrm{d}k, \quad \text{and} \quad \Psi_{+}^{+}(x,t)=\int_{+\infty}^{-\infty}\mathrm{e}^{i(\omega_k t-kx)}\mathrm{d}k, \quad \text{(b)} \end{aligned} \tag{1}$$

Whose solutions we can put in a generic way as (C. 12 of [3]):

$$\Psi_{(\pm)}^{[\pm]}(x,t)=[\mp i]B\frac{\mathrm{e}^{(\pm)i[\Delta k/2(\upsilon t-x)]}}{\upsilon t-x}\mathrm{e}^{[\pm]i(\omega_0 t-k_0 x)}, \tag{2}$$

that we can combine, covering all possibilities with respect to the direction of propagation (defined by the different signs of $(\pm)i$ in the two resulting exponentials). In which the initial factor $[\mp i]$ is introduced so that the real part of all of them has the real form:

$$\Psi^{\pm}(x,t) = \mp B \frac{\sin\left[\Delta k/2(\upsilon t - x)\right]}{\upsilon t - x} \mathrm{e}^{\pm i(\omega_0 t - k_0 x)} = \psi \mathrm{e}^{\pm i(\omega_0 t - k_0 x)}. \quad (3)$$

In particular, in [1] the combination (symmetrisation process) of the functions corresponding to Equation (1b) was developed in detail, giving rise to an SWP, which allowed us to obtain, using the Lorentz transform, applied to the value of $x' = a$,

$$\upsilon t - x = a\left(1 - \upsilon^2/c^2\right)^{1/2} = a\gamma^{-1}, \quad (4)$$

the energetic (expectation) value of the SWP and the configuration of that energy through the different ETE terms to which this characteristic SWP transformation gives rise, as we have already seen in Equation (32) of [1]:

$$\begin{aligned} \bar{E} &= A^2 \int \zeta^m(\upsilon)\mathrm{d}\upsilon + \zeta^\omega(\upsilon)\mathrm{d}\upsilon \\ &= A^2 \int \left(\zeta_k(\upsilon) + \zeta_f(\upsilon) + \zeta_\omega(\upsilon)\right)\mathrm{d}\upsilon = \bar{E}_k + \bar{E}_f + \bar{E}_\omega \\ &= \left(\frac{\bar{\lambda} b}{\pi a^3}\right)\sin[\Phi]_\upsilon \int_{\upsilon_o}^{\upsilon_f} \frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon \qquad \text{(a)} \\ &\quad - \left(\frac{\bar{\lambda}\Delta k b}{2\pi a^2}\right)c^2 \int \frac{\cos[\Phi_\nu]}{\nu}\mathrm{d}\nu \qquad \text{(b)} \\ &\quad + \left(\frac{\bar{\lambda}\omega b}{\pi a^2}\right)c \int \frac{\cos[\Phi_\nu]}{\left(1-\nu^2\right)^{1/2}\nu}\mathrm{d}\nu, \qquad \text{(c)} \end{aligned} \quad (5)$$

with

$$\Phi \equiv \left[\Delta k(\upsilon t - x)\right] = \left[\Delta k\left(a\gamma^{-1}\right)\right] = \left[\Delta k(a\nu)\right] \equiv \Phi_\nu, \quad (6)$$

where $\bar{\lambda} = \hbar[T]$ and $A^2 = 2B^2[T]$, where $B = (b/2\pi)^{1/2}$ is the normalisation space constant of Equation (3) for $b = 2/\Delta k$ [which we retain without simplifying in Equation (5b)]. Where Δk defines the interval of reciprocal waves ($2\pi/\lambda$) making up the wave group. An Equation (5) that we have called transmutation because it is nothing more than a calculation of the energy expectation value of the SWP (which entails a normalisation constant related to the workspace) which, as we will develop, contains the initial and final objects of any energy transition, that is, any energy form and the mechanisms of progression from one to another, attributable to different states or configurations derived from the process of symmetrisation and its subsequent evolution. Mechanisms between some energetic forms and others on which we could add a plus of versatility through the use of the alternative Equation (1a) or the combination of both types (which interchanges the sign of the different terms), for the purpose of guiding, at our convenience and according to the requirements of physical reality, the proposed energy balance. This may serve, in addition to our convenience, to find another way of relating the terms of Equation (5), that is, of manifesting the energy, different from the one we know and study here.

Sticking to the option (1b) developed, and being more concrete, the resulting function (5) allows us to obtain a value of expectation which participates in the corpuscular energy value, since that for:

$$m_r = \frac{\hbar b}{\pi a^3} = \frac{2\hbar \times [T]}{(\Delta k)\pi a^3} = A^2 \frac{\hbar}{a^3}, \tag{7}$$

i.e. for a mass (massive coefficient) expressed by the wave constituents of the wave function, the term (5a) corresponds to the kinetic expression E_k that we know, affected by the phase factor $\sin[\Phi]_\upsilon$:

$$\bar{E}_k = E_k \sin[\Phi]_\upsilon \quad \Rightarrow \quad \frac{\bar{E}_k}{\sin[\Phi]_\upsilon} = E_k, \tag{8a}$$

or, more explicitly:

$$\begin{aligned} \frac{\bar{E}_k}{\sin[\Phi]_\upsilon} &= \left(\frac{\hbar b}{\pi a^3}\right)\int_0^\upsilon \frac{\upsilon}{\gamma^{-3}} d\upsilon = \left(\frac{\hbar b}{\pi a^3}\right)\int_0^\upsilon \frac{\upsilon}{\left(1-\upsilon^2/c^2\right)^{3/2}} \mathrm{d}\upsilon \\ &= \left(\frac{\hbar b}{\pi a^3}\right) c^2 \left(\frac{1}{\left(1-\upsilon^2/c^2\right)^{1/2}} - 1\right) = m_r c^2 \left(\frac{1}{\left(1-\upsilon^2/c^2\right)^{1/2}} - 1\right) \\ &= m_r c^2 (\gamma - 1) = m_r \gamma c^2 - m_r c^2 = E_t - E_r = E_k, \end{aligned} \tag{8b}$$

while the other two terms in Equation (5), which are not kinetic, are of nature different necessarily, *i.e.* clear components of the corpuscular formation process taking place, or participants in the (bidirectional) energy transit between the initial electromagnetic objects, defined in Equation (5c), and the final ones, *i.e.* the material encapsulation of the wave packet envelope defined in Equation (5b), which we can associate with E_r also represented (as the reference value) in Equation (8b).

Initial and final objects of an electromagnetic character, or not, which, nevertheless, have a wave character through their evolution variable Φ_ν, mathematically equivalent to the variable $[\Phi]_\upsilon$ associated with the phase factor [as is evident in Equation (6)], but of quite different functionality (which we wanted to emphasise through the different notation), in that, although both evolve on υ, $\cos[\Phi_\upsilon]$ is part of an integral process on the variable (from which a value results), whereas in $\sin[\Phi]_\upsilon$ it is a function on this variable, which defines a value.

We can go further on the transmuting character of the equation (recovering some aspects shown in [1] to advance in this sense and for a merely introductory understanding of it), if instead of considering Equation (5) a sum of energy terms of (unknown) values, we associate to it a zero net energy balance and rewrite it, according to the initial and final products, already mentioned, in the process of formation (and constitution of the energy E_r of the mass at rest), which, for the sake of clarity, we could place on both sides of an equality:

$$\bar{E}_\omega = \bar{E}_k + \bar{E}_f \quad \rightarrow \quad \left(E_\omega = E_k + E_r\right), \tag{9}$$

which we will be able to do without altering the signs of the magnitudes [without the need to adopt the sign criterion or use the flexibility expressed above through

Equation (1a)] by virtue, as will be seen below, of the path of integration or definition of the same (its limits) in the integrals of the terms, which up to now have been undefined.

Equation (9) that, disregarding the phase factor ($\bar{E}_k \to E_k$) in Equation (8), we can put for a given inertial or relativistic mass m as:

$$E_\omega = E_k + E_r = m_r c^2 (\gamma - 1) + m_r c^2 = \gamma m_r c^2 = mc^2 = E_t, \tag{10}$$

which is capable of expressing, jointly through its three terms, the energy balance of all the phenomenology in which the three energy species intervene, insofar as they appear by themselves together in a single equation, *i.e.* we do not put them together or associate them ourselves [important distinction inherited from Equation (5)]. And capable, in particular, of expressing that phenomenology in which there is a total conversion, such as the production (and annihilation) of pairs, which for the most general case, for the inertial mass or a reference system in movement, we can put as:

$$(E_t = E_\omega = h\nu) = (mc^2 = E_k + E_r). \tag{11}$$

As well as expressing any other conversion of the primary energy of the first member, such as that fully assimilated in the photoelectric effect, in which all energy (except extraction energy) is developed as kinetic, or that partially assimilated from the Compton effect (Sec 2.4 of [4]).

While the phase factor $\sin[\Phi]_\upsilon$, even without knowing what it represents, allows us to understand the wave of matter of de Blogie, given that over the equation:

$$\begin{aligned} &\lambda_B = \frac{h}{p} = \frac{h}{m\upsilon} \Rightarrow \lambda_B^2 = \frac{h^2}{p^2} = \frac{h^2 c^2}{c^2 p^2} \\ &\Rightarrow (cp)^2 = \frac{h^2 c^2}{\lambda_B^2} = h^2 \nu_B^2 = (\hbar w_B)^2 = E_B^2 \\ &\overset{(\text{for } m_0 \neq 0)}{\neq} E_t^2 = (\hbar w)^2 = (cp)^2 + (m_o c^2)^2, \end{aligned} \tag{12}$$

and assuming that $E_B^2 = E_k^2$, it is evident that for $m_0 \neq 0$ there is no conversion process for $\hbar w_B$ but the necessary manifestation of that wave part associated with the corpuscular kinetic factor E_k, since only that factor (which is expressed through the quantity of movement as *cp*) intervenes in the associated diffraction process (Section 3.1 of [4]). To put it another way, it is evident from the above equation is that not E_k that is involved in the process but $\bar{E}_k$, *i.e.* a kinetic factor implicit in that wave expression, as revealed by Equation (8a).

In conclusion, it becomes clear (as far as this initial presentation allows) that the theoretical foundation of all the phenomenology (currently explained or not) and of the equivalence of both energies (presented in different members of an equality for this very reason), electromagnetic (which can circumstantially form a pulse) and corpuscular, lies Equation (5), and therefore in the common origin already treated of these energies (the SWP), and common nature. A common nature in which particles and pulses are the forms or species into which energy can be concretised, according to the corresponding terms $\bar{E}_f$ and $\bar{E}_\omega$ of Equation (5), *i.e.* Equation (5b) and (5c), which are the final-initial products of a process of creation. Process that conjuncturally may harbour an energy associated with motion (this is always the case in some system), or the initial-final of one of disintegration (in which, logically, the kinetic energy is not dissipated), as occurs in some particle decay processes.

In addition to other states or transformations involving them, in which the wave term acts as a primordial, transit or base energy form, and the corpuscular one (together with its kinetic energy), as a recurrent one which, according to certain limitations or conditions, gives rise to the whole structure of the elementary particles of matter, as we developed in a summarised (abbreviated but concise) way in [1], being this the most important (the most functional and specific) of the phase factor, and the one that allowed us to reach a phasic structure of the particles, that is, a structuring and hierarchisation of them, that we need to recapitulate to, as we said, make progress on the concepts.

Indeed, there we show how through a single condition for the phase factor ($\sin[\Phi]_\upsilon^{-q} = 0$) we can obtain the whole mass spectrum for fermions, *i.e.* an unnoticed pattern through it which justifies their masses, by converting the inertial energy into rest energy at the end of their action interval, which we call *phase(s)* $\phi = [\Phi]^{-q}$: $\Phi = \pi, 2\pi, \cdots$, which for our study we can restrict to the most elementary case $q = -1$ (that of electrons) in which $\phi = \Phi$ and the condition is:

$$\sin[\Phi]_\upsilon = 0 \tag{13}$$

A single condition which is none other than the final value recurrently reached by each phase $\Phi = \pi, 2\pi, \cdots$ in $\sin[\Phi]_\upsilon$ through the critical values υ_p^i, which will be the $\upsilon_1, \upsilon_2, \upsilon_3, \cdots$ of the different intervals of integration defined in Equation (5a), or intervals of application $\hat{\phi}_i \equiv [0, \upsilon_i] \simeq [0, c[$ of the phase (the path of the same in the corpuscular domain), which we call *field of velocities*, of which we also find different varieties, $\hat{\phi}_1, \hat{\phi}_2, \cdots$. In the same way, we can find a preceding velocity field $\hat{\phi}_0$, either of corpuscular or electromagnetic nature (with or without an associated particle), and others $\hat{\phi}_\nu$ (also deployed on the previous one), associated with neutrinos. Field of velocities that define the physical space in which the physical relations develop without solution of continuity, we could say, a homogeneous and bounded reality or vibrational state (for the electron is $\hat{\phi}_1$ until $\Phi_1 = \pi$ is reached for υ_1), given that from these frontier speeds, for $\sin[\Phi]_\upsilon = 0$, we have (at the generational level) a new particle and a new situation of rest [$\upsilon(\approx c) \to 0$].

Taking this to what we are dealing with, we could say that the term (5c) develops in a (previous) phase, the corpuscular result in term (5b) forms a later one, and the term (5a) is a hybrid form, which has a component that is represented in the corpuscular phase (E_k) and another component ($\sin[\Phi]_\upsilon$) that is not usually applicable in the corpuscular phase but in the other one, which is underlying all the others, and which governs them through its own annihilation

$\sin[\Phi]_{\upsilon} = 0$ for the speed $\upsilon = \upsilon_p$ of cycle jump or rupture. From this, we can conclude that, apart from the number of jumps (related to the phases Φ_i), there are conceptually or physically speaking two phases on a place of transit or interlude in its evolution, that is, two states (which we will characterise later) of a different nature.

A treatment that evidences a phenomenology regarding the generational jumps of particles, which at the same time revalidates the treatment and the equation on which it is based, as well as revalidating a host of theoretical and even paradigmatic elements, including a new hierarchical category for kinetic energy, or its elevation to the category of the other two (resulting indistinguishable), in that they can be unified or become any of them in the process [1]. To the point (and this is another paradigmatic change) of making real something that in Physics had been a chimera or a conceptual error of the relativistic treatment dragged on for a long time: that inertial mass is (can be) finally real mass.

Once this initial correspondence has been presented, we will be able to inquire further into the different aspects of Equation (5), to see what are the real similarities or differences with respect to the merely corpuscular behaviour and, in another way, what characteristics the expression reveals about the formation process. These are questions that we will ask by limiting the study term by term, on which we will necessarily have to invent a whole physics (construct it) or a way of operating under the new concepts, about which we will say "everything" that can be said at this point in time.

3. The First Term of the ETE

3.1. Everything about the Phase Factor

The natural question to ask now could be what role $\sin[\Phi]$ plays in Equation (5a), or Equation (5a) itself through that factor. To answer this, we must think about the process we are dealing with. By Equation (5) we are not calculating the energy of a particle but the energy of particle formation from a wave packet (from the SWP itself from its constituents). A formation that carries with it an energy and that obeys a certain process whose energy balance for a closed system is null. A process which, in short, is a process of sudden densification, such as that which necessarily occurs in collisions for this purpose, in which all the energy collapses, going from being photonic, if that is the case, to corpuscular, to a dense object with a kinetic development, which may be null for some relative system.

Consequently, whether we are talking about the formation of the particle derived from a previous annihilation (in which all the energy becomes of the electromagnetic species) and subsequent recombination, or about a first formation (from that same electromagnetic species), there will always exist from some relative system a term (5a) which will be nothing but an energy surplus or energy differential between the starting electromagnetic energy (characterised for each inertial reference system by its frequency) and the one made available for the corpuscular formation. A surplus of kinetic energy that will have to be returned in the annihilation processes (becoming tangible for all the relative systems in which it is pertinent to do so), through its extinction through condition (13) of the phase factor, as we have already seen to the generational changes in [1], and we will detail now, as the only way to carry it out in a sudden way.

The term $\bar{E}_k$ of Equation (5a) is, therefore, an extension or generalization of the relativistic dynamic expression E_k for this circumstance, as reflected in Equation (8) itself, shown by a wave term. Extension that is there, but which is not shown because its application in corpuscular phenomenology is non-existent (although it is present in all of it) except for the aforementioned annihilation processes ($\sin[\Phi]_\upsilon = 0$) or for those in which matter eventually manifests itself as a wave, either because of its duality (matter-wave) or because of the very process of material formation we are dealing with, which necessarily involves this duality. Generally speaking, in this attempt to interpret and reconcile the two physical realities, the term wave would only apply to those processes in which the dynamical parameters cannot reside circumstantially in the corpuscle or cannot manifest themselves through it.

On which it is worth reiterating that we speak of applicability and not of presence, since in all corpuscular phenomenology kinetic energy is represented by $\bar{E}_k$, although we only perceive its corpuscular component E_k (which according to the equations do not exist by itself), and that, consequently (we nuance), it is not that $\bar{E}_k$ is an extension or generalisation of E_k, but that E_k is a functional restriction of $\bar{E}_k$. A restriction that we can associate to $\sin[\Phi]_\upsilon = 1$ (although it does not necessarily have to be so, as we shall see) for this case, that is, for the one $\bar{E}_k = E_k$ and is given (shaping all our reality) after the process of formation (and its subsequent evolution), in which the dynamic parameters can reside in the corpuscle (which is why it does not do so explicitly in the phase factor).

Following on from the above, we can think that, in fact, we could have at some time $\sin[\Phi]_\upsilon = 1$ for the formed particle, since, whether it comes from a previous annihilation or change of generation ($\sin[\Phi]_\upsilon = 0$) or not (a process of initial formation or a dual state with $0 < \sin[\Phi]_\upsilon < 1$), at some point in the material creation the pro-corpuscle could present itself without kinetic energy ($E_k = 0$), densified but alien to any wave activity (equivalent to $\sin[\Phi]_\upsilon = 1$). In other words, if we say that at some time all the factors of Equation (5a) are undifferentiated within the integral of the equation, we are saying that $\sin[\Phi]_\upsilon$ does not exist as such or equivalently that $\sin[\Phi]_\upsilon = 1$.

What we cannot consider as true, given the dependence of the phase factor $\sin[\Phi]_\upsilon$ with υ ($[\Phi]_\upsilon = [\Delta k(\upsilon t - x)]$), is that it remains $\sin[\Phi]_\upsilon = 1$ for the subsequent evolution, which would even make the subsequent generational changes ($\sin[\Phi]_\upsilon = 0$) unfeasible. From which we conclude, since the energy integral evolves as if it were so ($\sin[\Phi]_\upsilon = 1$), that in this case, the phase factor is not applicable ($\sin[\Phi]_\upsilon \in]0,1[$) (because it is in another phase, as we have already mentioned) or is not effective in the calculation of the energy value (in fact we do not need it to know E_k), which would have been fixed ($\bar{E}_k = E_k$) through the value $\sin[\Phi]_\upsilon = 1$ previously reached after the formation of the corpuscle (which is what marks really this applicability).

That is to say, $\sin[\Phi]_\upsilon \left(\in]0,1[\right)$ is not applicable, after the formation of the particle, because the particle is already configured (another phase) or because it represents, in the best case, a sort of inappreciable perturbation or an average null perturbation on the base state $\sin[\Phi]_\upsilon = 1$ reached. It follows, on the other hand, that the evolution of the variable υ for $\sin[\Phi]_\upsilon > 0$, that is to say, for all of $\upsilon < \upsilon_p$, ceases (definitively) to have any repercussion or to be significant, and consequently, we can consider the notational suppression (which we had even remarked) of the said variable $\sin[\Phi] \equiv \sin[\Phi]_\upsilon$ to be appropriate, although it continues to play its role.

Notwithstanding this simplification, the phase factor is still there, it is not extinguished and has its importance beyond the energy computation. A kinetic energy without a phase factor, as a principle of corpuscular promotion and extinction, is, in fact, less feasible, and less assumable for the understanding of physical processes (that is a way towards questioning the current physics paradigm), than a phase factor without a energy element associated clearly. A phase factor that, in the worst case, would always allow us to establish the connection between the two species, build that energy element from its absence, and understand the changes it involves, which is ultimately what we have done in all the previous development [1].

In addition to the above, the term (5a) does not speak exclusively of the kinetic energy of the particle, which implies a massive coefficient as a reference, but of that same energy as a coefficient or multiplying factor, in such a way that the same as in Equation (3) we had for the wave function Ψ an envelope $\psi = \sin\left[\Delta k/2\left(\upsilon t - x\right)\right] / \left(\upsilon t - x\right)$ or body of waves, which represented an amplitude or measurable magnitude on an elementary wave $e^{\pm i(k_0 x - w_0 t)}$, here we have, energetically speaking, the group constituted in dynamic particle (assimilated by E_k), also as amplitude or measurable magnitude, on the sine part of the pulse $\sin[\Phi] = \sin\left[\Delta k\left(\upsilon t - x\right)\right]$, that is, on the form of the pulse itself but without packing, taken as an elementary wave or energy carrier.

If we look at this is what we have achieved by the SWP with respect to the formation of a wave packet type, the construction of a carrier (coming out of the energy integral), which is not just any carrier but an (energy) carrier containing the group velocity (and not the phase velocity, as usual) and the momentum of the wave packet, that is, of the material particle, which is why this carrier, which we have called the phase factor, should be called the phase factor of the material object or wave of the matter, which more clearly stated would be nothing but a matter wave, since it embodies this functionality and fulfils all the formal requirements, supporting the dynamical characteristics of the particle.

Although a wave packet is made up of a wave body or modulated amplitude and its carrier wave (two factors, therefore), the energy of the carrier has no impact on the energy balance (all the energy is concentrated in that amplitude). In our case, although our carrier is for an amplitude, which represents energy (supported on a particle), it is a wave, *i.e.* we are also talking about two elements ($E_k \times \sin[\Phi]$) with a multiplicative relation, in which, likewise, the carrier ($\sin[\Phi]$) represents an invaluable summand in the total energy balance because all the energy is concentrated in the other summand (E_k).

Consequently, we have a phase factor as a carrier which, like any carrier, does not affect the energy value of the particle, and therefore any $\sin[\Phi] \neq 0$ state is inapplicable, so that, being $\sin[\Phi] = 1$ transparent, $\sin[\Phi] \in]0,1[$ appears, at best, as a negligible energy perturbation on the newly constituted material state, capable, however, of collapsing or undoing the modulation it supports (as any carrier would do), when it itself, for $\sin[\Phi] = 0$, collapses.

The formation of the corpuscle, therefore, which, as we said, corresponds in reality to the energetic transit of the other two terms, does not annihilate totally the wave nature of the first of them, but leaves the oscillating part, that elementary wave (carrier), which ordinarily does not manifest itself (all our dynamics is sufficiently understood without it), as a sample or vestige (matter wave), outside the spatial limits of the particle, but associated with it. And, in particular (about the differentiated phenomenology of application), as a manifestable wave register (wave-particle duality) of its corpuscular kinetic parameters, as an authentic carrier or catalyst of the physical reality of the particle, of its true and hidden wave nature. This is the least restricted functionality of the phase factor $\sin[\Phi]$.

Wave-particle duality which takes place, either by means of the transfer of these parameters to the phase factor (which in these circumstances will fulfil $\sin[\Phi] \in]0,1[$) or their simple application (if they already contain them), as a consequence of the circumstantial loss of the unequivocal corpuscular character of a first stage in the process (which may remain unfinished) of deformation (inverse formation), which entails the impossibility of expressing itself corpuscularly or the necessity of expressing itself in another way. This leads to the conclusion not only of the relevance of $\sin[\Phi] \in]0,1[$ in the evolution of the phase in the corpuscular state (already validated) but also of the same in the process of corpuscular formation and deformation (wave-corpuscle duality).

Understanding, however, that in these circumstances of duality, although the state is not entirely corpuscular, the kinetic treatment of Equation (8) continues to be valid because the process continues to be carried out in the integral limits (phase) established for it in Equation (5a), contrary to what happens in other processes of inverse formation in which these limits are lost due to the total loss of the corpuscular character (decays), or in which other limits are taken (decreasing generational change). The latter processes in which Equation (8) is still valid, but for a different energy balance, as a consequence of the reconversion of almost all the rest energy into kinetic energy, per the relation between the new rest mass and the previous one, now inertial, as occurs (in the inverse sense) in the increasing generational change [1]. Processes that, on the other hand, bring us face to face with the idea of the principle of relativity and its fulfilment and importance.

Indeed, the conservation of the principle of relativity, as fulfilled by E_k in Equation (8), is indispensable and can be crucial in itself to understand what happens with respect to the wave factor $\sin[\Phi]$ and to characterise its behaviour mathematically, that is, to represent mathematically this dual behaviour, both in terms of the discontinuous change between $\sin[\Phi]=0$ and $\sin[\Phi]=1$ and in terms of the materiality and kinetic changes of the associated energy, which are the two states variables that interest us really for the formation, while $\sin[\Phi]\in\,]0,1[$ belongs to the stable state of matter (including that of duality).

For this, we have to place ourselves in the idea that for inertial systems there is no intrinsic kinetic energy, but rather a relationship between systems as a function of their relative speed, just as potential energy is a function of their height difference. Consequently, Equation (5a) cannot change as a function of the different speeds (between $\upsilon=\upsilon_p$, which fulfils $\sin[\Phi]=0$, and the subsequent $\upsilon=0$) anymore or in a different way than it does for the different observers.

Continuing with this idea, we can consider a starting situation or collapse in which $\sin[\Phi]=0$ is fulfilled for a reference system associated with a pro-corpuscle, which, once constituted as a corpuscle, evolves, due to the energy surplus, with $\sin[\Phi]\neq 0$ for an infinitesimal variation of υ with respect to its original system. For a particle in its original system, we will have passed from a situation in which it is instantaneously $\sin[\Phi]=0$ to one in which, de facto, it is always $E_k=\overline{E}_k$ in Equation (8), even though the phase factor $\sin[\Phi]$ may evolve, from $\sin[\Phi]=1$ to $\sin[\Phi]\neq 1$, as explained above.

The sine function is not capable of making this behaviour possible by itself. We cannot explain this jumping behaviour (which obeys boundary conditions), in fact, or emulate it utilising any function. The appropriate way to represent this behaviour is by means of an improper function such as the Dirac delta or impulse function, that is, by this type of distribution, which we can also associate directly with the mass, since this is the one that changes its situation really:

$$\overline{E}_k=\left(\frac{\hbar 2}{\pi a^3\Delta k}\right)\sin[\Phi]_\upsilon\int_{\upsilon_o}^{\upsilon_f}\frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon \triangleq \left(\frac{\hbar 2}{\pi a^3\Delta k}\right)\int_{\upsilon=0}^{\upsilon<\upsilon_p}\delta(\upsilon)\mathrm{d}\upsilon\int_{\upsilon_o}^{\upsilon_f}\frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon$$
$$=\left(\frac{\hbar 2}{\pi a^3\Delta k}\int_{\upsilon=0}^{\upsilon<\upsilon_p}\delta(\upsilon)\mathrm{d}\upsilon\right)\int_{\upsilon_o}^{\upsilon_f}\frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon, \tag{14}$$
$$\delta(\upsilon)\left[\begin{matrix}\infty & \text{for } \upsilon=0\\ 0 & \text{for } \upsilon\neq 0\end{matrix}\right. \quad \text{verifying} \quad \int_{-\infty}^{+\infty}\delta(\upsilon)\mathrm{d}x=1.$$

We are not saying, and hence the notation used ($\triangleq$), that the function $\sin[\Phi]>0$ and the Dirac delta are equivalent, but rather that circumstantially the function, together with the physical constraints, can behave or be defined as such, for any final speed $\upsilon_f < \upsilon_p$.

A distribution that we can express in another way to extend the behaviour of the equation to the state $\sin[\Phi] = 0$.

$$\begin{aligned}\bar{E}_k &\triangleq \left[\frac{\hbar 2}{\pi a^3 \Delta k}\left(1 - \int_{\upsilon>0}^{\upsilon_p} \delta\left(\upsilon - \upsilon_p\right) \mathrm{d}\upsilon\right)\right] \int_{\upsilon_o}^{\upsilon_f} \frac{\upsilon}{\gamma^{-3}} \mathrm{d}\upsilon \\ &= \left(\frac{\hbar 2}{\pi a^3 \Delta k} \Gamma[\Phi]\right) \int_{\upsilon_o}^{\upsilon_f} \frac{\upsilon}{\gamma^{-3}} \mathrm{d}\upsilon = m_R \int_{\upsilon_o}^{\upsilon_f} \frac{\upsilon}{\gamma^{-3}} \mathrm{d}\upsilon.\end{aligned} \tag{15}$$

In which, similarly, we are not saying (according to the *equal delta*) that the original function $\sin[\Phi]$ and the distribution $\Gamma[\Phi]$ are equivalent, but that $\sin[\Phi]$ together with the physical conditioners can behave or be defined as such, which is nothing but as a filter function that only reaches two states, that of pass, for $\Gamma[\Phi] = 1$, and that of non-pass or annihilation when $\Gamma[\Phi] = 0$, for $\upsilon = \upsilon_p$. State of annihilation from which it will derive, according to the phase concept and the application of certain conditions [that expressed in Equation (13), in a recurring manner], all phenomenology of matter, that is, its creation and transformation, in correspondence with the phase changes associated with these processes, which we will deal with in a study that requires this one, in which we will detail and quantify for each of the classes of particles what has already been advanced in [1]. Phase changes for which the principle of relativity is not violated either, since what the preceding expression says is that there is an energy relation between two differentiated states (before and after the phase change) whose transit occurs suddenly, both of which can have a certain additional kinetic energy depending on the reference system. Not different from what happens in any elementary particle transition between the initial and final products.

Quantum Entanglement

Although the theoretical model developed could at some point present some kind of limitation (for what is not within its reach, it has it obviously), what it makes clear so far is that it provides a framework associated with the process of construction of matter and its wave carrier (phase factor) with which to explain and contrast many phenomenologies associated with this construction, which is thus presented as an interpretative key or as a kind of starting point, which it will rightfully be if from it we are capable of tackling various questions of physics.

Questions of physics that are and will be mainly of an underlying reality and difficult transit, that which necessarily starts from a basic and deep starting point and which is usually of little interest or forgotten as it generates a less mechanistic or pragmatic physical knowledge as was once the case with quantum entanglement, which we are going to deal with next. A knowledge that is nonetheless the true knowledge, the true physics, the one we will have to strive for if we want to know our deep reality, the one that leads to the physical principles, which we can only reach from a dissection or prospective treatment such as the one we are dealing with here. A less mechanistic treatment which, nevertheless, and in a strict or literal sense, is more physical than the one developed on the basis of a mathematical artifice, which does not speak of reality but of a scheme of it.

In accordance with this dissection, we have established a wave symmetrisation process that gives rise to a free particle and with it to a matter wave (phase factor) that represents a memory of the primordial wave state (wave packet) and a register of the kinetic variables and, if desired, as such a wave, of a quantum state concerning certain observables, through a suitable dimensional extension and a suitable representation or SU symmetry group on it. A phase factor which, as we have seen in the previous development, and as shown in the generational changes [1], far from being an element at the mercy of the particle, is to a large extent, occasionally and for relevant and/or transit issues, the causal element: we can assure that physics is much more difficult or of impossible solutions when the cause with effect is inverted.

Having said this, and following this prospect, it is not difficult to realise that this process of symmetrisation is in itself a process of entanglement of wave packets which gives rise to the aforementioned particle and a single or non-interlaced wave (phase factor). A single wave that is susceptible of establish an entanglement process with the phase factor of another particle, which gives rise to a dual phase factor, or directly a single shared one (in the case of the generation of pairs), and with this to a combination of states of these particles or quantum entanglement of the same, as described by Schrödinger in 1935 in connection with the critique of quantum mechanics formulated by EPR [2], which, although unsuccessful, highlighted the paradox or theoretical vacuum that persists to this day, and which now concerns us.

A dual factor phase that would be wherever the two particles are situated, whether they are close to each other or at the far ends of the universe, because it is nothing but a plane wave of certain characteristics which, like its two forming phase factors, is the promoter of any change or alteration of the material whole.

To which we should add that it is not only that the plane wave can be at the far ends of the universe, but that it is quite possible (we can consider it as true), according to what we will develop in the following section about the phases, that this distance does not exist or is null in the system of light (proper length). This is not strange in the relativistic environment, which opens up a host of possibilities (which we will not discuss here) concerning the true nature of that plane wave and of light as such.

Apart from this, which requires a more specific development, the measurement or detection of a particle at one of the distant extremes would, according to this scheme, do nothing more than act on the dual phase factor, which is in charge of materialising the relevant changes in each of the particles (or preserving the coherence of states), that is, assigning and, if necessary, collapsing to the corresponding states instantaneously. The action is instantaneous because the impact on the particles of what happens in the dual phase factor is not produced by a continuous function in time but is a sudden change of state representable by an improper function. That is, it is not produced by transmission of an electromagnetic nature, even if such a nature is present, but through an alteration of the wave construction process (symmetrisation) or of the waves of the already constructed object, where the phase factor is a "wave by-product" of that construction and therefore an element bi-univocally and indissolubly related to the forming waves, in the same way as the two members of some equality ($1+1-1+1=2$), in which we cannot alter the list of summands (a state as a consequence of the sum of waves) without altering the final result (the resulting wave), because they are equivalent members.

Consider in this respect that in origin we are dealing with wave packets that are constructed by the superposition of waves, which is nothing more than the sum (integral) of waves in the form represented in Equation (1), in which the carrier is part of its result, as we saw in Equation (3). A result that will have no energetic impact on the particle through Equation (5) but a memory of that energetic state and, by extension, of its other properties (as the spin), in such a way that, on one side (member of the equality) the particle may have one representation of that spin (which we then notice when it collapses) and from another a function that accounts for it.

For ease of understanding, and without loss of generality, we can imagine that the aforementioned dual phase factor (entanglement of phase factors) is established by the direct connection of the phase factor 1 (F1) of particle 1 (P1) and the phase factor 2 (F2) of particle 2 (P2), as shown in **Figure 1(a)**. For the entanglement of this dual phase factor, which in this case we can consider shared, we can add a pair of superposed states, $\psi = \alpha\left|\uparrow_1\downarrow_2\right\rangle + \beta\left|\downarrow_1\uparrow_2\right\rangle = \alpha\phi_a + \beta\phi_b$, characteristic of quantum entanglement, which would give rise, as shown in **Figure 1(b)**, to the splitting of the phase factor, according to the two possibilities or combinations of states for a null value of the quantum variable in question, such as spin (spin=0), and for a single direction, which allows us to simplify the study we intend with a clear scheme and free of other quantum particularities.

From here, and in this context that we propose, when we detect state $\left|\uparrow_1\right\rangle$ in P1, as a consequence of the measurement process, it is not that a transmission mechanism of information is produced so that P2 collapses to state $\left|\downarrow_2\right\rangle$, it is that the function ψ has collapsed to state ϕ_a as a consequence of the observation, at the same time that it discards or extinguishes the branch ϕ_b (see **Figure 1(c)**). Which on the one hand gives rise to the value measured in P1 and, on the other hand, establishes an instantaneous correlation of states for P2. In this case, and continuing with the small numerical analogy of the construction process, on $\mathrm{P1} \equiv 1+1-1+1 = \left[2 \equiv (\psi)\right] = 1+3-2 \equiv \mathrm{P2}$ one cannot modify (fix) the result 2 of ψ (resulting from the sum of waves) without modifying (fixing) in an analogous way P1 and P2 (the list of summands), and vice versa.

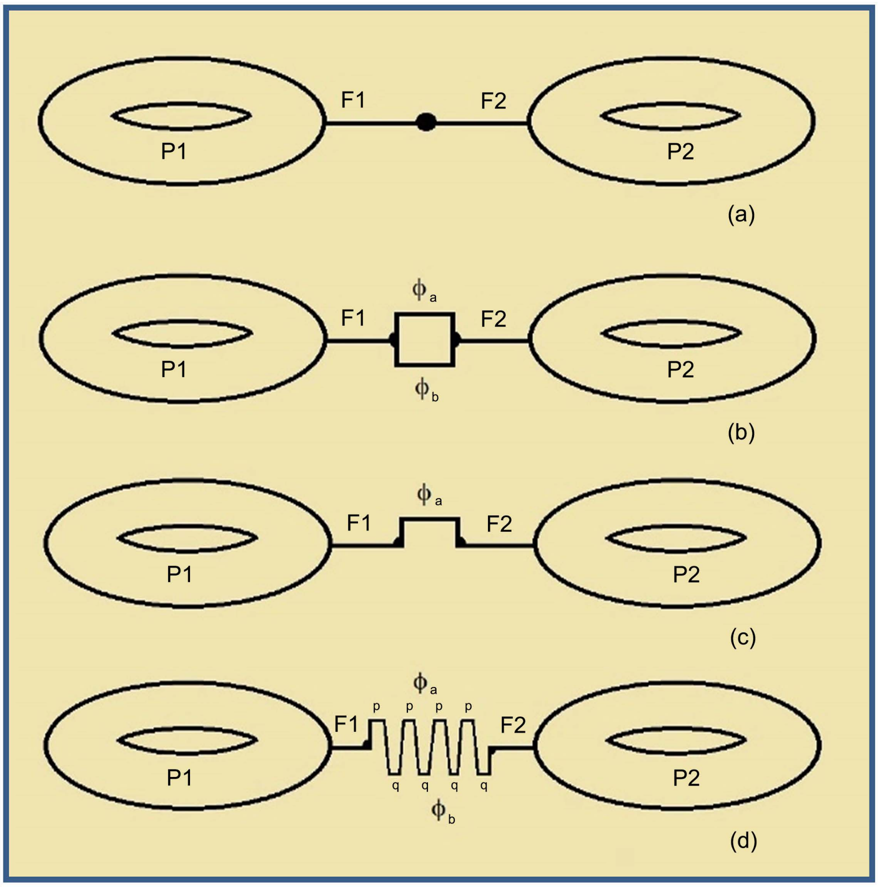

Figure 1. Different phases of quantum entanglement, established through the phase factor of the two entangled particles.

Being purist with phenomenology, and according to the mentioned coherence between the parts (derived from the construction process), we would be in a continuous change of states of the two particles and in a continuous alternating establishment and extinction or back and forth of the paths ϕ_a and ϕ_b according to the probability determined by the wave function, in such a way that it is the measurement of the observable that freezes the system to the state that results in the measurement, that involves the whole system and that at that instant has that configuration. An alternation or back-and-forth as depicted in **Figure 1(d)**, where the sum of the (p) legs has a length α and the sum of the (q) legs has a length β, which is but discrete expressions of the probability of encountering one state or the other, it being when the measurement reaches the system at a leg (p), corresponding to the state $\left|\uparrow_1\right\rangle$ that we have taken as an example, that the system de facto passes to the configuration shown in **Figure 1(c)**.

The solution to the question of quantum entanglement is to understand that there is no action at a distance between two bodies when they have some form of connection at a distance, and that the action between them, in this case, can be instantaneous despite a (quasi) infinite distance, in the same way, that the action on two bodies attached to the ends of an ideal rope is instantaneous when we pull the centre of the rope downwards, since the impulse in this (ideal) case is instantaneous. Or, to put it even better (leaving aside this ideal character), when we pull the two ends of the string downwards (and here is the key), as happens with the branch, **Figure 1(c)**, which is extinguished from the phase factor, since it is all of it which has the information and operates at the ends, so that there is no distant communication between the objects (particles) but two objects close to their respective sources of information, there being consequently no superluminal communication and no break in the principle of locality.

A simile that helps us support or conclude in a more formal way that the way to transfer information for these purposes is, essentially and without alternatives, through transversal action (and not longitudinal action between extremes), with which the entire length of the phase factor is affected at the same time. Which is not difficult to implement through the participation of another similar wave with a phase shift (that modulates) or an inverse one (that cancels), or through the collapse condition seen in Equation (13) and used for generational changes of particles, among other possibilities, known or not, derived fundamentally from the idea of construction, to transmit information. The question is not so strange actually, since this is what we do when we measure in the act of observation: act with a wave (photon). The difference is that the wave not only acts on the observed particle but also on a system of solidarity items, which seems natural.

Everything illustrated serves to exemplify how the mechanism of identification and transmission of information from a quantum state to the extremes is effectively carried out by simply extinguishing or disabling the combination of non-representative states (or the persistence of representative states at the same extremes) through transversal action, although not to clearly show what makes it possible. In effect and as we said, the transmission of a quantum state is, through the process presented (as would be required of any theory that seeks to resolve the EPR paradox), more effective, simultaneous, and faster (as well as immediate), than that which would derive from the speed of light (without violating causality), but it is (and this is what is important) the real character of the phase factor what makes this possible. That is, not being a physical entelechy is what makes this possible or effective, making it possible for the alteration of the states (as physically compiled through the superposition of waves) to have physical consequences in the particles (correlation), and making there exist a pre-established end-to-end physical longitudinal path on which to exert a transversal action, a channel on which the observation wave can act. This, on the other hand, endorses the legitimate and real character of this phase factor and that of the theoretical framework that promotes it, which is ultimately what establishes the connection between this factor and the particle and that which is ultimately established between particles.

This, which makes phenomenology possible and explains it conceptually, highlights the undeniable need to take the development of our explanations down a notch, to bring them much closer to the subjects and the nature of the objects. With this, any attempt to explore these phenomenologies must be carried out through this undulatory framework, of which I am providing the bases, or by connecting any other with it, as it is the only one that contains the information and can provide us with it, it being understood as unfruitful, therefore, to go deeper into quantum entanglement, or to deal with what has already been said, from the quantum formalism without establishing this connection. It is not up to us now to establish it, nor is it in the pretensions of this work, which is more interested in laying those foundations and in developing, in this case, everything that Equation (5) suggests to us.

3.2. Everything about the Mass

Now it is a priority to establish the energetic correspondence of the different terms and particularly the second distinction between (5a) and (8) for the relativistic kinetic energy, which is determined or characterized by its mass m_r,

$$\begin{aligned} m_r &= \frac{\hbar b}{\pi a^3} = \frac{2\hbar \times [T]}{\pi a^3 \Delta k} = \frac{2h \times [T]}{\pi a^3 (2\pi) \Delta k} = \frac{h \times [T]}{\pi^2 a^3 (2\pi \Delta \kappa)} \\ &= \frac{h \times [T](\Delta\lambda/2\pi)}{V} = \frac{h \times [T] \Delta ƛ}{V}, \end{aligned} \tag{16}$$

as a concretisation or representation of a sort of *massive coefficient* of the wave group related to its amplitude, which is determined by the dimensional value a of the particle (proper size) and by $\Delta k = 2b^{-1}$, associated with the normalisation constant A explicit in Equation (6). Massive coefficient that, according to the last member of Equation (16), we can understand as related to a volumetric density (of some energy representation $\hbar[T]$) defined by $\Delta ƛ$ for a volume V proportional to π^2, that is, for the volume of a toroid (as already anticipated in **Figure 1**) that fulfils the relation $2r^2 R = a^3$, given that in this case:

$$V = 2\pi R \times \pi r^2 = 2\pi^2 r^2 R = \pi^2 a^3, \tag{17}$$

as a physical and geometric structure resulting from the symmetrisation or entanglement process of two groups of waves facing each other by its opposite or complementary movement as represented in Equation (1b).

A massive coefficient that we see that is conformed in Equation (16) by variables of two different natures, a corpuscular one, which is geometrical and energetic, and $\Delta ƛ = \Delta\lambda/2\pi$ which is purely undulatory. A distinction that will have physical consequences that we will deal with later, which also has a mathematical representation, given that it is because of this differentiated or heterogeneous and non-miscible nature that we have been able to maintain the π value associated with the elements of one species and the other differentiated, that is, what has allowed (and obliged) us to use Δk and not $\Delta \kappa$ as a variable of wave evolution (despite $\Delta k = 2\pi\kappa$ being fulfilled). Having, consequently, the possibility of taking out the value $1/2\pi$ as a factor or integrating it in $\Delta\lambda$ and reaching an angular measure $\Delta ƛ$ of the variable, in correspondence with the angular representation Δk of the wave number, which is also the same that we have used from the beginning and which gives rise to the normalisation constant.

According to the definition of mass as a volumetric density of $\Delta ƛ$ expressed by Equation (16), it is also evident that the higher the coefficient m_r the smaller the volume $V(a)$ has to be for all particles sharing the same normalisation constant, since in the same particles $\Delta ƛ$ is a fixed and unique value characteristic of the wave group, because it is fulfilled (in what is a relationship of constants):

$$2\hbar\Delta ƛ = \hbar b. \tag{18}$$

From Equation (16) we also obtain $m_r \times V = m_r\left(\pi^2 a^3\right) = \pi b\hbar$, which shows that for a single characteristic initial value of the wave group (its width), defined by the constant b [or, as we explained in Equation (5), its corresponding and unique normalisation constant ($b \leftrightarrow B \leftrightarrow A$)], there are several theoretical possibilities, $m_r^1 \times V_1, m_r^2 \times V_2, \cdots$, in the left-hand member (infinite without any other limitation).

That is, from Equation (16) we derive an element of uniqueness and an element of diversity, which, taken to the SM, correspond respectively to the identity of a class of particles and to the different generations of particles of that class, restricted in practice to the discrete number of known families. Different generations of particles that in the strict sense do not share a single normalization value b either, since this depends on the velocity field $\widehat{\phi}_i$ itself, but that we can consider it as such, as it supposes a negligible correction in most cases (all except one), such as seen in [1].

As the mass is expressed in Equation (16) we cannot say much more about it or, as we said, about its energetic representation, despite being well-defined and dimensionally homogeneous. A point that will be seen even more clearly if in Equation (16) we represent mass in its energetic form and, since in general $E = \hbar w = h\nu = h \times [T]^{-1}$, rewrite the constant $\hbar$ as an energetic magnitude $E_\hbar$ associated with the inverse of the time unit, according to its units
$\hbar = E_\hbar \times [T] = E_\hbar / \nu_\hbar$, that is,

$$\begin{aligned}\frac{E_r}{c^2} = m_r &= \frac{\hbar \times [T]\Delta ƛ}{V} = \frac{E_\hbar \times [T]^2 \Delta ƛ}{\pi^2 a^3} = \frac{E_\hbar \times [T]^2}{\pi^2 a^2}\left(\frac{\Delta ƛ}{a}\right) \\ &= \frac{E_\hbar}{\pi^2 (a/t)^2}\left(\frac{\Delta ƛ}{a}\right) = \left(\frac{\Delta ƛ}{\pi^2 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2} = \left(\frac{\Delta \lambda}{2\pi^3 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2} = \Omega\frac{E_\hbar}{\upsilon_\hbar^2},\end{aligned} \tag{19}$$

where it is indeed evident, given that Ω is dimensionless, that the first and last members of Equation (19), thanks to the additional time dimension within $ƛ$ resulting from the integral solution reached in Equation (5), are dimensionally homogeneous, and that, consequently, so are all the members of the equation, and those of Equation (16) in the beginning. An additional time dimension that has allowed us to define a velocity $\upsilon_\hbar$ (over two of the three a values), which we can correspondingly call our proper speed.

What has been said about mass m_r is already enough for our purposes, that is, to achieve physical coherence, to put it in context, and to proceed further in the study of the terms. We can, however, say more on the basis of Equation (19), things which involve an exercise in prospection, an attempt to delineate the true nature of matter, and that of the space in which it arises as such and which is implicit in it, as well as of the true relation between it and radiation, and the true and necessary overlap, which we will analyse at the end, between the two factors seen, m_r and $\sin[\Phi]$, since it is the latter that allows the former to retain the apparently lost three-dimensionality in Equation (19) as a consequence of the conformation of the dimensionless factor Ω or absorption of a dimension in it.

3.2.1. The Maximum Speed (External or Free), the Minimum Speed (Proper or Internal), and the Forms of E_r

Indeed, by means of Equation (19) it is not only evident not only what has already been referred to but also, taking into consideration the first and last members [which we write in Equation (20a) for clarity],

$$\overset{\text{(a1)}}{\frac{E_r}{c^2}} = m_r = \overset{\text{(a2)}}{\frac{E_\hbar}{\upsilon_\hbar^2}}(\Omega) = \left] \begin{array}{ll} \Rightarrow E_\hbar = \left(\frac{1}{\Omega}\right) m_r \upsilon_\hbar^2 & \text{(b1)} \\ \Rightarrow E_r = E_\hbar \left(\frac{c}{\upsilon_\hbar}\right)^2 (\Omega) & \text{(b2)} \end{array} \right.$$

$$\Downarrow \qquad\qquad \Downarrow \tag{20}$$

$$E_r = m_r c^2 \ \text{(b3)} \quad \Leftarrow \quad E_r = \left(E_\hbar \frac{\Omega}{\upsilon_\hbar^2}\right) c^2, \quad \text{(c)}$$

That the energy of the particle E_r is proportional to the basic energy of wave $E_\hbar$. Being the proportionality factor, as we see in Equation (20b2), a combination of the one established by Ω itself and the square of the one established between the speed c associated to the (free) wave itself and the speed $\upsilon_\hbar$ (of which we did not know until now), which we could understand as a minimum or residual and internal speed of the particle (of the constrained wave associated to *a*), or, as we have already said, a proper or inherent speed. Besides being able to establish the usual form of proportionality in Equation (20b3), from Equation (20a1) or from the previous one, as a consequence of a different organisation and consideration, shown in Equation (20c), of the factors involved.

Consequently, and according to the unprecedented Equation (20b2), in the energy E_r of the particle is present a proportionality factor expressed through the speeds associated with the two states or forms of being of the particle, susceptible of being connected by a process (as it could be that of annihilation or its inverse) that can make us think that equally those speeds are the essence of that process. Or that these speeds are the true relationship, as opposed to the usual Equation (20b3) in which the (corpuscular) variable m_r paradoxically computes the (corpuscular) energy value E_r over the variable c (which is not corpuscular), as it follows from the equivalence of Equation (20a1), or as opposed to Equation (20b1), also unprecedented, which we can similarly obtain on Equation

(20a2), in which the speed $\upsilon_\hbar$, which is part of this mass (and is corpuscular through the spatial dimension *a*), is related to an energy value, $E_\hbar$ associated to $\hbar$ which is not corpuscular or purely wave-like. That is to say, Equation (20b2) is the (only) expression that accounts, through both speeds, for the transformation or accommodation between some corpuscular and non-corpuscular energy, which homogenises the members, as opposed to the others, clearly heterogeneous without the presence of an adaptive element, since m_r is not, and its equivalent in Equation (20c), although revealing, is not either.

A speed $\upsilon_\hbar$ that is a minimum not because there cannot be one less than it in the physical world but because for the particle, with $a = \Delta x'$, any displacement of the variable *x* takes place over that minimum, which is an (internal) maximum in it, which implies its own size, so that a certain $dx \to 0$ at one extreme represents $(\Delta x' + dx) = \Delta x'$ at the other.

A speed $\upsilon_\hbar$ that can even make us think, according to its non-zero value, that speed *c* is as maximum because it is associated with a maximum limit (already defined in the field of velocities $\hat{\phi}_i = [0, c[$) as speed $\upsilon_\hbar$ is minimum because it is associated with a minimum limit (from which we could consider that in truth $\hat{\phi}_i = [\upsilon_\hbar, c[$, that is, that any speed starts from that minimum $\upsilon_\hbar$). Which, in turn, can make us think that speed *c* (the same for all $\hat{\phi}_i$), responding to a mirror behaviour or the same way of developing, may obey a similar conceptualisation referring to a maximum size, that is, that of being defined through a spatial or topological constant, ς, on which a dynamic functionality or additional condition is then implemented, as has occurred for $\upsilon_\hbar$ with respect to the two factors *a* affected and, therefore, in two of the three spatial coordinates of the toroid, without, however, affecting its toroidal shape or physiognomy. In other words, we can think that just as there is a minimum (proper) size for the wave packet, there is a maximum (proper) size ς when it is unfolded, intimately linked to *c*, as we will develop later [nothing extraordinary if we consider that we start from a SWP and the equivalence existing between a wave packet and a pulse (see C. 20 of [3])].

3.2.2. Two-Dimensional Wavefront (c^2) and Volume

Due to the additional dynamical functional ($a \to \upsilon_\hbar$), which we have just quoted, and the equivalent mass dependencies on $E_\hbar$ in Equation (19) we can write the following mass energy expression:

$$m_r = \left(\frac{\Delta\lambda}{\pi^2 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2} = E_\hbar\left(\frac{\Delta\lambda}{\pi^2 \upsilon_\hbar^2 a}\right) = E_\hbar\left(\frac{\Delta\lambda}{V/t^2}\right) = E_\hbar\left(\frac{\Delta\hat{\lambda}}{\hat{V}}\right), \tag{21}$$

On which we can emphasize again that only two of the three spatial dimensions *a* of the volume of the toroid are affected (by time) and become speed, just as *c* is affected bidimensionally (by the two formants), and for this reason, it is c^2 in the energy expressions, and not c^3 (as we would expect in some three-dimensional space), both in Equation (5a), we are working on, and in Equation (5b), characteristics of m_r, but not in Equation (5c), which, being purely wave-like, retains its one-dimensional character in the expression, *i.e.* one dimension less (as in the other cases) than its physical reality.

In the case of E_k, we pass through the symmetrisation process from a bi-one-dimensional system to a three-dimensional one characterised in the equations themselves by c^3 (and a^3), which finally decays to c^2 as a consequence of the integration process for the construction of the reference energy value (see Appendix A in [1]), which is none other than that of the rest energy also associated, as can be seen in Equation (5b), to c^2. We could say that in the integration process, solved in Equation (8b), c^2 reflets the construction of the particle and the other variable c (through the speed υ), of which (5b) does not specify, a proportionality factor with respect to rest, expressed by γ, which is derived from the dynamic process.

The system decays to c^2, as a consequence, as we said, of having combined two waves (and not three), and of having, therefore, only two of the dimensions (the original υ_h) that generating capacity or the construction. Being the third dimension (the remaining parameter a), consequently, something that arises or is created [which does not exist as such, in fact, in Equation (5b), or has yet another form], and creates the volume, the space proper, from two one-dimensional waves that do not have it in themselves. Two one-dimensional waves that form a two-dimensional pattern that, although it does not account for the volume, does account for the surface front or characteristic envelope that forms it, which we call the spherical wavefront, intimately related to it, as we shall see, in its state of expansion or dematerialization, in the same way as υ_h^2 is, although modelling the toroidal form, for the other state.

3.2.3. The Mass in Extrinsic Space, and the Mass in Intrinsic Space

An analogous change to that made in Equation (20a1) to determine the value of energy E_r as a function of rest mass and speed [Equation (20b3)], is that made in Equation (20a2) for $E_\hbar$, allowing us to establish, in a more formal way [Equation (20b1)], an alternative definition for mass (or understanding of what it is through its functionality). A definition that does not have to do with what it can energetically develop ($E_r = m_r c^2$), but with what it is energetically in itself (in relation to the individual energy of a wave) when it is constrained in the particle, which is its true definition, the one we were trying to seek, and which in Equation (16) was still veiled.

This dual character of mass is represented clearly in the two starting Equations (20a1) and (20a2) in which the mass is the ratio of proportionality of two fractions (already referred to above for the speeds). The usual definition (extrinsic) of mass at rest, expressed in the first of these, is given by a ratio between the energy it is capable of delivering and the characteristic speed c^2 when this occurs, associated with the situation of maximum expansion or development of the velocity field ($\hat{\phi}_c \equiv [0, c]$). The self-definition or intrinsic definition (expressed in the second one) does not speak of any process (at least not of expansion), is the internal relationship of a given energy pattern $E_\hbar$ (associated with the wave through *h*) and the characteristic speed υ_h, associated with the situation of maximum constriction or proper size *a*, which is that of the particle in question.

A self or state definition, and not a process definition (although it is also the end of a process) which, nevertheless, like the usual one, is hybrid or composed of elements of the two systems, states, or species, which is certainly paradoxical (as we have already mentioned). This will be better understood if, by cross-multiplying Equation (20a1) and (20a2), we obtain an equation free of these heterogeneities, since Ω is a simple dimensionless dividing factor, that is,

$$E_h c^2 = E_r \left(\upsilon_h^2 / \Omega\right) \equiv E_r \varpi_h^2 = cte, \tag{22}$$

where it is emphasised that the energy E_r associated with m_r, applied to the constrained kinetic surface ϖ_h^2 that is natural to it (material wavefront effective) is equivalent to the unit energy E_h of the original wave applied to the surface that is natural to it (its two-dimensional expansion c^2), that of the spherical wavefront. That is to say, these members are not only equal but are each composed of homogeneous elements of the same nature, which makes the equation a more essential or true-to-reality equation that differentiates states, a sort of invariant since it retains its value, which expresses the potential to be concretised in a certain energy value (in the form appropriate to their status). What will allow us, together with the previous analysis, to go deeper into the nature of the processes of creation and annihilation, and of the variables at play.

Indeed, the first member of Equation (22) highlights, in a first reading, that it is the energy E_h of a wave, applied to its whole spherical front c^2, which we can find (or serves as a reference) when a particle annihilates and passes to an immaterial state, and that is why the energy of a particle (when this occurs) comes as a function of c^2 (resolving the above paradox), and that, correspondingly (last member), it is the energy E_r of a particle, applied to its effective material wavefront ϖ_h^2, which represents (serves as a reference) when a particle is created.

In addition to finding in these equivalences that $E_r \gg E_h$ because $\varpi_h^2 \ll c^2$, and that the smaller the wavefront υ_h^2 (or the effective one ϖ_h^2) the greater the energy E_r, which is the only one we have any notion of in a process of creation, not being this value but the result of normalising the last member through ϖ_h^2, given that c^2 (initial state) does not evolve (through υ_h^2) to $\varpi_h^2 = 1^2$ (final state) but to an indeterminate ϖ_h^2 value.

Normalisation which gives rise either to Equation (20c), in which it is emphasised (in a second reading, as a consequence of this normalisation) that it is not a unitary energy E_h which is applied on c^2 (or finally gives rise with E_r by means of this application) but a density of this energy (E_h / ϖ_h^2) in this space, or to the equivalent Equation (20b2), where it is a unitary energy, although not applied to a continuous space but ascribed to a discrete number of elements (c^2 / ϖ_h^2) in this space. Where it becomes clear that ϖ_h is also an intrinsic velocity which, because of its relation to *c* and E_h, can be called *unit velocity*. A dual interpretation that, supported by the equations, is not at all strange if we take into account that which exists in itself between a pulse (finite single wave) and a wave packet, which implies the modulation of the former (with k wave-number).

Such a material system could have different values $\varpi_\hbar^2$ (different masses and different energies), for which the energy expansion of E_h through c^2 is identical (third member), being able to change only the density of the (intrinsic) wave energy $E_h / \varpi_\hbar^2$ from which the same would take place, which is nothing but the density of wave energy to which the wave is forced in the process of material constriction. Since the constriction undergone does not depend on c^2 (which is common and universal, either as initial or final state), we will have to divide by this factor the value of the energy E_r in Equation (22) or, better, in the different forms of Equation (20), to know the extent of that constriction in E_h:

$$m_r = \frac{E_r}{c^2} = \frac{E_\hbar \left(\frac{c}{\upsilon_\hbar}\right)^2 (\Omega)}{c^2} = \frac{\left(\frac{E_\hbar}{\upsilon_\hbar^2}\Omega\right)\cancel{c}^2}{\cancel{c}^2} = \left(\frac{E_\hbar}{\upsilon_\hbar^2}\Omega\right) = \frac{E_\hbar}{\varpi_\hbar^2}. \qquad (23)$$

(23b3) (23b2) (23c) (23a2)

It follows that the same is constant and is the rest mass m_r, as we could imagine and appears in Equation (20a2), highlighting that, in accordance with the corresponding Equation (23) and what has been said above, the Equation (20c) reflects better the corpuscular energetic reality (in relation to the corpuscle) than Equation (20b2), which nevertheless expresses better what really happens in the particle (there is no density applicable to c^2 but an energy E_h repeated a number of times $c^2 / \varpi_\hbar^2$), which will be convenient to preserve the presentation of the starting unitary value E_h and to differentiate it from its dynamics, and better, as we shall see in the following epigraph, to characterise the resulting or equivalent electromagnetic energy.

The formation of the particle requires the use (as formation energy) of the expanded energy, and its contraction and consequent finite spatial localisation. If the particle size were $\varpi_\hbar^2 = 1$ (for which we define an energy density $E_\hbar^o$), from Equation (22) we would have $E_r = E_\hbar^o c^2$, but this is not so, being, on the contrary, that generally $\varpi_\hbar^2 < 1$ and that only some $\varpi_\hbar^2$ values are possible, so that E_h has to be expressed for $\varpi_\hbar^2 < 1$, that is, to increase its density value ($E_h > E_\hbar^o$), until reaching the value $\varpi_\hbar^2$ of state, equivalent to increasing the ratio $c^2 / \varpi_\hbar^2$ and the $E_h / \varpi_\hbar^2$ (which we call m_r) characteristic of the particle in question. The reason why a value m_r is stable, and not another, is precisely what we have already explained in the theoretical body concerning generational changes. A m_r corresponds to a value E_k, which in turn corresponds to the Lorentz factor γ that reaches the condition (13) in the phase factor.

3.2.4. The Origin of the Frequency

We have seen that the energy E_r is determined with respect to the energy surface density [m_r, expressed in Equation (20a2)], by the real dimension of the sample (that is, by c^2) in the velocity field $\hat{\phi}_c \equiv [0, c]$, which finally takes the form given in Equation (20c), and that the same is equivalent to establishing how many units $\upsilon_\hbar^2$, affected by Ω, with energy $E_\hbar$, there are in that sample c^2, as expressed in Equation (20b2). That is, the number $c^2/\varpi_\hbar^2$ of units, according to Equation (23), which coincides, moreover, with the number of cycles C associated with the frequency, on which it is not difficult to compose or recover the frequency and put the value of the energy as a function of it, in accordance with the expression:

$$\left[E_r = m_r c^2\right] = E_\hbar\left(\frac{c^2}{\varpi_\hbar^2}\right) = \left[E_\hbar(\Omega)\left(\frac{c^2}{\upsilon_\hbar^2}\right) = h[T]^{-1}(\Omega)\left(\frac{\varsigma^2\chi^2}{a^2\chi^2}\right)\right]$$
$$\overset{\varsigma=na}{=} h[T]^{-1}(\Omega)\left(\frac{n^2a^2}{a^2}\right) = h\left(\frac{n^2\Omega}{t}\right) = h\left(\frac{C}{t}\right) = h\left(\frac{c^2/\varpi_\hbar^2}{t}\right) = \left[h\nu = E_r\right]. \quad (24)$$

This shows that the number of cycles C is ultimately a ratio (affected by Ω) between the maximum size of the wave ς^2 when it is expanded and the minimum size a^2 when it is constrained in corpuscular size.

We see, in short, that the real relation between the two usual ways of expressing E_r, explained in the initial and final brackets of Equation (24), can be seen in the central bracket of the same, where it is shown that the radiant energy of a mass m_r, as a function of the frequency and the energy unit $E_\hbar$ (associated with $\hbar$ or h), is related to the number of times that energy unit $E_\hbar$ is contained in that mass, which in turn is the squared function of the ratio between the speed c of the velocity field (maximum speed in a system) and the unit velocity $\varpi_\hbar$.

From there, we know the frequency ν for the mass of a given particle, and we are also able to know (although we do not develop it here) the values of Ω, which would allow us to calculate n and a, which would allow us to calculate (as already mentioned) ς, that is, the spatial expansion or natural dimension of the wave associated with the speed c, and with it the relation between the two, and subsequently calculate $\upsilon_\hbar$.

It is worth pointing out several things in this respect. On the one hand, to reiterate that we have no guarantee of the existence of ς, only that it is plausible under the finite character of the wave that characterises a pulse. On the other hand, to point out that, regardless of its existence, what has been said is correct, since ν is reached from the previous relationship between speeds, on which we can make the subsequent change (to space) as we wish, that is, for any value of time. Finally, although, indeed, we do not know of the existence of ς (as we do not know of $\upsilon_\hbar$, except for all that has been developed above), it is also true that we have ν as a constant of proportionality of two ratios (a frequency is always how many times something small occurs within something large), of which we have a known element in each of them, a and c, which allows us to know the other, in both, which justifies this frequency.

3.2.5. On the Most Elementary of the Elementary

Although E_r is only a total energy computation established from E_h, and there is, according to Equation (20c), no evolution between them, *i.e.* no dependence, we can conceptualise, according to Equation (22), such a relationship between the two, the particle maximum (E_r) and the elementary wave minimum ($E_\hbar$), insofar as we can establish an explicit connection or correspondence between these energies and their fields of application, that, as can be seen in Equation (25), lies in the ratio of the wavefronts and the proportion established for the same value m_r :

$$\frac{E_r}{E_\hbar}=\frac{c^2}{\varpi_\hbar^2}=\frac{m_r c^2}{m_r\varpi_\hbar^2}=\frac{m_r\left[\varpi_\hbar^2\left(c^2/\varpi_\hbar^2\right)\right]}{m_r\varpi_\hbar^2}=\frac{\not{h}\nu}{\not{h}\nu_h}. \tag{25}$$

That is to say, both energies are sustained in m_r as an intrinsic quality, for a different wavefront or field of application, [as was already evident in Equation (20a1) and Equation (20a2), with which we could equally have reached the preceding equation]. It is further emphasised that for E_r extended (electromagnetic) we are dealing with the same elementary wave $E_\hbar$ with that intrinsic quality, repeated a number of times in an expanded (serial) manner at c^2, which gives rise to multiple cycles and a frequency ν, that repeating element being a single cycle, $\nu_h \equiv 1$, characterised by $\varpi_\hbar^2$ ($\rightarrow \upsilon_\hbar^2 \rightarrow a^2$). Whereas for E_r constrained (corpuscular) we are dealing with the same wave repeated a number of times over itself (in parallel), which does not give rise to a travelling wave of a given frequency but to a stationary pattern of *k* waves (over the same cycle) or a wavenumber *k* (a wave packet), *i.e.* a different idea of repetition to the previous one, which we can express as follows:

$$E_r = m_r c^2 = h\nu = hC\nu_h = n^2\Omega h\nu_h \triangleq kh\nu_h = km_r\varpi_\hbar^2 = kE_\hbar = E_r, \tag{26}$$

while on the other hand, it generates the additional dimension *a*, which is, in the end, what happens when the SWP is generated.

An additional dimension which gives volume (forms the toroid) but which may give the impression of being fictitious, since, in addition to it, a variable is incorporated in Equation (19), which absorbs or neutralises it (hence the dimensionlessness of Ω), as we have already mentioned, which brings us face to face with the requirement of having to combine both circumstances and to overcome the paradox and possible objection. An objection that may go unnoticed without an in-depth study of the equation or even (conversely) be overcome with what has already been presented, which has its own weight, without the need for additional arguments.

Indeed, before entering fully into the question, it must be observed that Equation (19) already establishes that the mass responds (dimensionally speaking) to the forms given in the two fractions [which we can see in Equation (20a) more clearly], so that, this not being a problem in Equation (20a1) for consigning the mass, it should not be a problem in Equation (20a2) simply because of the appearance of Ω as a converting element of the different nature of the two expressions, or the adaptation of the electromagnetic form to the corpuscular one, which is basically what it does and what we are basically dealing with in the whole development. Having said this, it is evident (complementing the above), that the particle is not only m_r, but $M_r \equiv m_r \times \sin[\Phi]$, which by Equation (21) takes the form $M_r = (E_h/\widehat{V})(\Delta\hat{\lambda}\sin[\Phi]) \equiv M_c \times M_\omega$. Consequently, what has to be dimensionally homogeneous in Equation (19) is this expression, which is and remains as we have presented it in Equation (19) if we remove the dimensionless factor $\sin[\Phi]$.

From there, as part of the aforementioned conversion, part M_ω of factor M_c is required to act on $\widehat{V}$, which does not imply that $\widehat{V}$ of M_c loses its volumetric character, given that although *a* of $\widehat{V}$ and $\Delta\hat{\lambda}$ (which make up Ω) have the same dimensions, they have them in different phases or natures, which cannot compensate each other, neutralise each other, or bring their respective states together. What it does do, and hence the dimensional balance of the combination, when there is an energetic development in the form expressed by Equation (20a1).

To understand the basis of the aforementioned combination, which surely sheds light on what we are dealing with, we have to take into consideration firstly that for $\hat{\Omega} \equiv \Omega/2\pi^3$ in Equation (19), $\hat{\Omega}^{-1} = a \times \Delta(1/\lambda) = a \times \Delta\kappa$, which is how it appears in Equation (16). Secondly, that $a \times \Delta\kappa = \Delta x' \times \Delta\kappa$, given that, although we have not said so explicitly, $a = x'$ in Equation (4) determines a size thanks to the fact that it is referred to the point $x' = 0$ of an interval. Thirdly that $\hat{\Omega}^{-1} = \Delta x' \times \Delta\kappa$ is an expression intimately linked to the construction of wave packets, which fulfils $\hat{\Omega}^{-1} \geq 1/4\pi$ (clearly dimensionless), *i.e.* an expression by means of which it is shown that there is a dependence between one variable and another in the construction of a wave packet. A dependence that can be calculated by the Fourier integral (see Sect. 3.4 of [4]) and which is analogous, applying the Blogie-Einstein relations to the variables, to the principle of indeterminacy.

We see that the construction process itself of the SWP specifies this product and the value of inequality for that specific construction, *i.e.* that $\hat{\Omega}^{-1}$ is present in the construction of this SWP, which in some way represents an endorsement of the process or a signature attesting to its existence through the aforementioned indissoluble dependence of the variables of $\hat{\Omega}^{-1}$ in this construction. Regardless of the path or final affiliation of each of these variables: in this case, $\Delta x'$ takes the path of being $\Delta x'$ because it is already in itself a spatial dimension, and $\Delta\kappa$, of inverse dimension to the previous one, the one of maintaining, in addition to the mathematical condition, the dimensionality of the total system. A dependence represented by $\hat{\Omega}^{-1}$ which in its direct form, $\hat{\Omega} = (\Delta\lambda/a)$ [already present in Equation (19)], describes better than any other the nature of what we are dealing with, since it relates the width of the continuous spectrum of wavelengths used to form the particle (characteristic of the particle family) to the width of the particle, which gives an idea of the importance of the dimensionless parameter Ω, which ultimately becomes.

We can say that we have a two-dimensional system, the one that appears in

Equation (20a1), and the system of Equation (20a2) with the same two-dimensionality, that of the two formants, which is provided in the process of symmetrisation with an additional dimension and its inverse dimension, of heterogeneous natures, in such a way that internally it remains two-dimensional [and hence the dimensional equivalence with the usual energy form given in Equation (20a1)] but that, on the other hand, externally it is three-dimensional with an extra one-dimensional undulatory component. An extra one-dimensional component which associated with the phase factor $\sin[\Phi]$ is only a scale factor, which [as it appears in the last equivalence of Equation (27)] can be incorpored, with no dimensional impact, into the particle, which is thus strictly three-dimensional.

$$\begin{aligned} M_r &= m_r \sin[\Phi] = M_c \times M_\omega = \frac{E_\hbar \Delta\hat{\lambda}}{\widehat{V}} \sin[\Phi] = \frac{E_\hbar}{\widehat{V}} \frac{\sin[\Phi]}{\Delta k} \\ &= \frac{E_\hbar}{\widehat{V}} \Delta\hat{\lambda} \sin[\Phi] = \frac{E_\hbar \|\Delta\hat{\lambda}\|}{\widehat{V}} \left(\frac{\Delta\hat{\lambda} \sin[\Phi]}{\|\Delta\hat{\lambda}\|} \right) \equiv m_c \times m_\omega, \end{aligned} \tag{27}$$

While dissociated (first equivalence) allows us to dispense with the phase factor he for mass m_r (as we have been using it) and to say that it is both three-dimensional (because a^3 physically is) and two-dimensional (because internally it is), this duality being a duality derived from the very essence of the process of formation, that is, of remaining internally what it was [and for this reason it is also a wave density ($\Delta\hat{\lambda}/\widehat{V}$)] despite being something else afterwards.

4. The Second Term of the ETE

Looking back over the route taken, we have obtained three integrals, two of which correspond to the corpuscular part and the other to the wave part. After having analyzed the first corpuscular term and seeing that it agrees with the energy of movement, it seems obvious that the corpuscular term (5b) is the energetic term of rest, since the energy of a particle is formed *per se* from these two things, and given that, moreover, the way it has been achieved, and the form in which it is presented, everything seems to indicate that it is.

To confirm this fit, however, we will first have to define the limits of the function that makes up this term. We could think (as a first option) that since the term (5a) is defined in the interval $[0,c[$, there is a sort of sequence ($]c,0]+[0,c[$) by which (5b) could be defined in $[c,0]$, since the state of rest is $\upsilon = 0$ and we are talking about the energy of formation of a mass at rest, which also suggests to us the idea of densification as a process of formation of the same, which is from an electromagnetic origin that also demands, in this initial state, what is inherent to its undulatory nature, that is, a starting speed $\upsilon \approx c$.

However, and contrary to what we may think, we can establish through the equations that, since the limits for kinetic energy in Equation (5a) are $\upsilon = 0$ and any $\upsilon \in [0,c[= \hat{\phi}_1$ associated with phase Φ_1, those are the same limits for the integral (5b) of the second term [which according to Equation (6) corresponds to the interval $[1,0[$ for the non-dimensional variable ν], given that this integral for $\upsilon = c$ ($\nu = 0$) it is not integrable and that it is initially composed (see annex A in [1]) of two other integrals, one of which is part of Equation (5a), which already has its integration path defined. Consequently, with $\Phi_\nu = [\Delta k(av)] = [\mathrm{T}v]$, we have:

$$\begin{aligned}\bar{E}_f &= A^2\int(\zeta_f(\nu))\mathrm{d}\nu = -\left(\frac{\hbar\Delta kb}{2\pi a^2}\right)c^2\int\frac{\cos[\mathrm{T}\nu]}{\nu}\mathrm{d}\nu \\ &= -\left(\frac{\hbar\Delta kb}{2\pi a^2}\right)CosIntegral(\Phi)\Big]\!\Big]_{\nu=1}^{\nu>0}c^2 = -\left(\frac{\hbar\Delta kb}{2\pi a^2}\right)(\alpha_-^k)\times c^2.\end{aligned} \tag{28}$$

In which we see, as a detail, that the evolution of the integral remains circumscribed to the factor α_-^k, which is accompanied by the formation mass m_f or fixed coefficient of the process, which as such is presented precisely as that base element or precursor of m_r. An Equation (28) in which, as expected, the value of energy remains as a factor on c^2, that is, as a mass on c^2, formed on the cosine integral ($-\alpha_-^k$), which we can even represent for $T = 1$ and $T = 100$ (**Figure 2**),

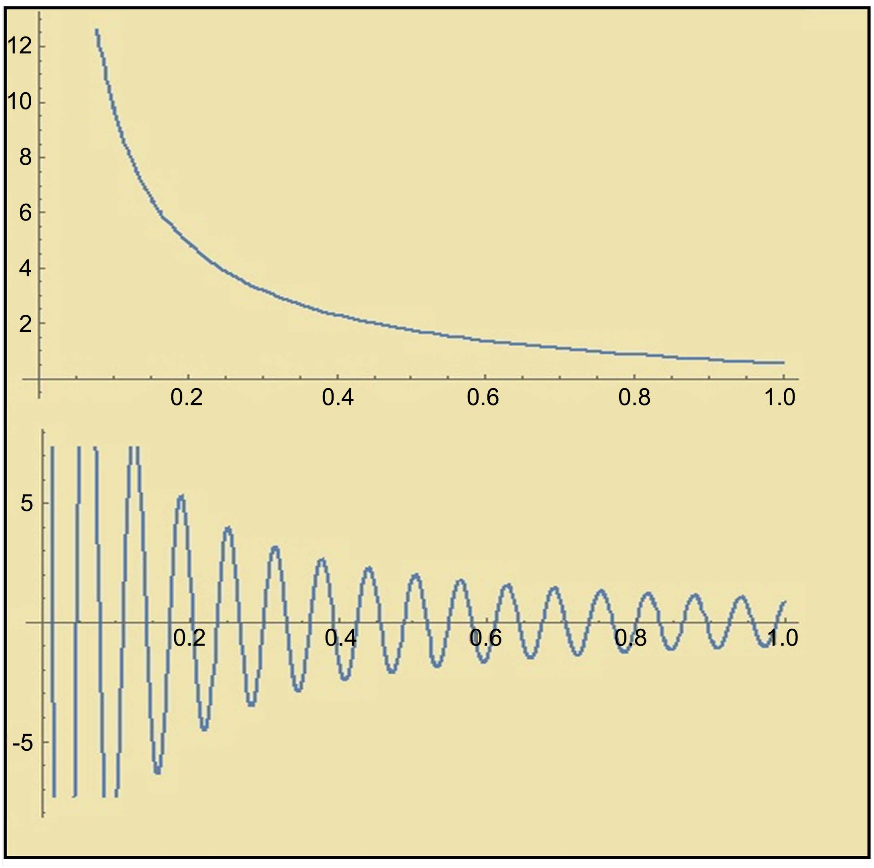

Figure 2. Function ($-\alpha_-^k$) for $\bar{E}_f$.

And that we can even express in a more compiled form if, taking into account that α_-^k is negative (hence the notation used), we absorb the sign of the integral through $\alpha_+^k = -\alpha_-^k$, and make $\Delta\tilde{k} = \alpha_+^k\Delta k$, that is:

$$\bar{E}_f = -(m_f)(\alpha_-^k)\times c^2 = -\left(\frac{\hbar\Delta kb}{2\pi a^2}\right)(\alpha_-^k)\times c^2 \cong \left(\frac{\hbar\Delta\tilde{k}b}{2\pi a^2}\right)c^2 = m_r c^2. \quad (29)$$

This saved, Equation (28), through its upper limit, indicates that the energy necessary for the formation increases (we could say that it yields negative energy) and that this formation occurs at some instant due to some circumstance ($\sin[\Phi]_\upsilon = 0$) or boundary condition for a speed $\upsilon = c - \varepsilon$, which for a later phase [that developed by (5a)] could be related to $\upsilon = |0 - \varepsilon| = \varepsilon = \upsilon_h$, that is, the proper and minimum speed characteristic of the same or, what is the same, with the size *a* of the new particle generated, given that ε and υ_h progress in the same way.

A boundary condition that occurs or coincides with a certain energy value as a function of α_+^k, which in turn coincides, in practice, with a recognizable value of mass m_r (of the generated phase), at which point the term becomes "frozen" and unable to store any other amount of energy, which is forced to develop in another way, that is, by the term kinetic (as we are used to seeing it) in the newly released phase.

We are initially relating the term under study (5b) to the kinetic term (5a) because once the latter appears, the relationship with the former (which supports it) is fundamental and inevitable, without prejudice to the fact that before its appearance (which may not occur) the initial relationship for the formation of a mass without massive background is established with the term (5c).

Consequently, without taking into consideration for the moment a supposed first formation derived from the term (5c), the path (of formation and materialisation) corresponds, according to the first two terms of Equation (5), with successive sequences up to $\upsilon = |c - \varepsilon|$ from the initial starting point $\upsilon = 0$ (we could say $\upsilon = \upsilon_h$) in each one of them, in which, consequently, $\upsilon \approx 0$ is not reached at the interface by a decrease of υ without solution of continuity, but through a collapse or abrupt change (after the continuous increase), as we have already was the case with (5a) regarding the generational change.

On the one hand, they are successive sequences because after a sequence of formation (5b) follows a sequence (5a), but on the other hand they are concurrent sequences because every end of a sequence (5a) finally gives rise (except by force majeure) to a new mass (change of generation) which is expressed in the form (5b), which is that which finally fixes or defines any other type of energy (whether that kinetic energy is transformed transitorily into electromagnetic after the collapse or whether it does so directly) in corpuscular energy.

That is, with the fixed value, (5a) continues its evolution from that point as $\upsilon = \upsilon_h$ and with the form (8) until it finds a new condition, that is, a new possibility of decaying or expressing that energy through the form (5b), varying its energy value through α_+^k and, properly speaking, that of the mass through the change of the parameters that form it, making the new m_r equal to the preceding inertial mass, which will serve as the new energy standard in Equation (5a).

As a consequence of this concomitance of cycles, a priori we would not know if a cycle (5b) that conforms our m_r obeys to the first formation, via (5c), or to a previous cycle (5a), but what we can be sure of is that on that m_r value there is a subsequent cycle (5a), which will give rise (except for the last generation) to a formation via (5b), which would allow us to equate the energies through the expressions (5c) and (5a) (since the energy values do) and, consequently, to treat any m_r (and the m_f implicit) through a cycle (5a), including the m_r of first formation, assigning it a precursor particle m_i or an equivalent starting energy. That is:

$$\begin{aligned}\bar{E}_{f1} &= m_r c^2 = \Delta\bar{E}_{f0} + \bar{E}_{f0} = \left(m_r c^2 - m_i c^2\right) + \bar{E}_{f0} \\ &= \int_{\nu=1}^{\nu>0} \Upsilon_m \mathrm{d}\nu + \bar{E}_i = m_i c^2\left(\gamma - 1\right) + m_i c^2 = m_i \gamma c^2.\end{aligned} \tag{30}$$

Treatment that follows naturally from the already explained correspondence between cycles and, taken to its extreme, allows us to treat the process from a discrete or corpuscular perspective, being able to establish the corpuscular energy balance as the sum of the initial energy E_i associated with m_i and the mass or corpuscular energy E_m in all its phases, in such a way that,

$$\begin{aligned}E_t &= \Delta E + E_i = \left[\left(E_t - E_r\right) + \left(E_r - E_i\right)\right] + E_i \\ &= E_k + \Delta E_f + E_i = E_k + E_f = E_m + E_i.\end{aligned} \tag{31}$$

A corpuscular perspective that could even be not unique but iterated if the term E_f, according to Equation (30), is put in a more general way.

$$\bar{E}_f = \sum_{i=0} \Delta\bar{E}_{fi} + \bar{E}_{f0}. \tag{32}$$

An initial or precursor particle m_i for which m_r represents its equivalent inertial mass that, unlike that developed kinetically, is consolidated as a mass at rest through the described process, which is designed and used, in fact, for this purpose, that is, to transform the kinetic inertial mass (which is otherwise a simple energy equivalence) into real mass (the inertial mass of one term is the rest mass of the other). With this, the process of (anti)matter formation is supported by the massive increase of a pre-existing particle, as part of the phenomenology or as an essential part of the process, that is, as a chosen tactic: that of establishing energetically speaking a stable reserve and another dynamic part, and a transfer between one and the other on demand.

This would allow us to understand Equation (5a) and Equation (5b) as identical processes, and hence the integral limits are the same, one with the cycle completed and stable, and the other incomplete and dynamic. Processes that, taken to the extreme, that is, for $m_i \to 0$, would be circumscribed to the transition phenomena between a non-corpuscular form and another corpuscular one, universally accepted for the creation of particles, as specific forms of other more general processes of densification and said more rigorously of phase changes, which are ultimately, as we shall see, the precursors (applicable to processes such as particle annihilation), as well as being conceptually superior.

All the issues discussed will be better understood if we take into account that both forms of energy have a common starting point, that is, if we take into account the inevitable interrelation between these forms with the envelope of the general Equation (2), as its origin factor, which we can verify by comparing Equation (8b) and Equation (29), with respect to the common factor m_r, to see that the two terms can be equated, that both represent a different evolution of c^2 (through an integral on different variables, υ and ν) on a common term that is the mass.

Progressing in the proposed equalisation, we know how kinetic energy evolved with υ ($\gamma > 1$), but not how energy $E_r = m_r c^2$ as such evolved in Equation (8), and it is through Equation (28) that we find that such evolution is also a function of $\nu(\upsilon)$, that is, of speed υ, in a necessarily different velocity field $\widehat{\phi}_0$, *i.e.* for another phase Φ_0, which we can presume to be earlier. And going further, we find that this evolution shapes the mass m_r, and that, where its formation concludes ($\Phi_\nu = \left[\Delta k(a\nu)\right]$ of Equation (6) stops being creator and becomes the dynamic $\Phi = \left[\Delta k\left(a\gamma^{-1}\right)\right]$), another different evolution begins (on υ) without solution of continuity with respect to the massive coefficient m_r, which from there on remains invariant, being able, consequently, to equate or relate it. In effect, it is fulfilled:

$$\left(\frac{\hbar b}{\pi a^3}\right) = \left(\frac{\hbar \Delta\tilde{k} b}{2\pi a^2}\right) \Rightarrow \frac{\Delta\tilde{k}}{2} = \frac{1}{a} \Rightarrow a = \frac{2}{\Delta\tilde{k}} = \frac{2}{\alpha_+^k \Delta k}. \tag{33}$$

This implies that it is at this point that the mass m_r is consolidated and becomes invariant when the three-dimensionality of the particle is consolidated, that is, when as a consequence of the development or evolution of $\Delta\tilde{k}$ the particle conforms to the third coordinate, in accordance with the equivalence shown. Equivalence that we can also put as:

$$a = \frac{2}{\alpha_+^k \Delta k} = \frac{2}{\alpha_+^k 2\pi\Delta\kappa} = \frac{\Delta\lambda}{\alpha_+^k \pi} = \frac{\Delta x}{\alpha_+^k \pi}, \tag{34}$$

where it becomes clear, together with what is indicated in Equation (16), that the dimensional value $a = \Delta x'$ of the particle is determined, through a specific value of Δk, by the size $\Delta\lambda = \Delta x$ (the former referred, as the latter is by definition, to a cycle), and by a specific value of the cosine integral α_+^k, which thus acts as a *formation density factor* ($\alpha_+^k = \Delta\lambda / a\pi$), that is, as a constant of the process defined by Equation (34), in such a way that it can be said that all the parameters of the process are related and fixed to values that we can know from the known ones. A formation density that we can put as a function of starting elements in our Equation (34) such as:

$$2\left(a \times \Delta k\right)^{-1} = \alpha_+^k, \tag{35}$$

where on the one hand we would have this factor as the inverse of the product of two wave group variables, once it is constituted, and on the other hand as the final result of the integral in the construction process.

We can see that the product $\Delta kb = 2$ allows a simplification in Equation (29) and the related equations, which however we have not carried out (as we have already done) in order to maintain the same format in all the terms and a better pattern for comparison, such as that carried out in Equation (33). Also because Equation (29) is already expressing through the integral the final state of a process in which Equation (5b) is analogous to Equation (5a) for m_r, according to Equation (33), which gives rise to the fact that, as we saw in Equation (19), the two variables represent different things, as a consequence of being applied in different phases.

We can understand this in a better way, which will also be valid for the formation process, if instead of considering Δk, we consider $\Delta \tilde{k}$, which will be the variable to be taken into account at all times in this process. In this case, and in accordance with Equation (33) we would not have in Equation (19) a factor Ω that separates the two phases, but $\Omega = \left(\alpha_+^k / \pi^2\right)$, which highlights, in a way, that the coordinate a is not differentiated and that there is, consequently, no effective three-dimensionality in the creation process. This would indicate that in Equation (5b) the process of densification through the change of speeds (size) is fundamentally present, but not that of spatiality, which is the one that is finally achieved with the effective creation of the particle.

Phase Change

We have spoken of densification or change of density of the physical object, and we have also spoken of change of phase, which is a superior or broader concept than the previous one, which encompasses it but which implies something else, and which is necessary to take into account to understand, or at least interpret, the physical process that takes place, beyond what it mathematically represents through the evolution of $\Phi = \pi, 2\pi, \cdots$ or the change from a certain interval of that evolution (phase) to another.

In line with this, when we have changed the variable x' to its own size a in Equation (4) by means of the Lorentz transformation, we have accepted this change of phase because we have not used Equation (4) to relate two relative systems but to relate all relative systems to a system that is not, which is obviously another phase or differentiated state. We have accepted it in the same way that we accept it in an ice cube, which in its solid phase retains its shape (regardless of the container it was originally given, and of all deformable liquid systems), and continues to retain its shape even if we throw it into the sea.

The question, therefore, is not whether or not we accept something by looking at what happens to the contents of a bucket of liquid water, but whether or not it is possible to fix its geometry or dimensional structure. Analyzing the equations of a group of waves without considering this, we can say that the group is dispersed and that it cannot represent matter, which is what obviously happens to a group of waves if you do not "freeze" it, and you do not fix its dimensions when throwing it into a sea of waves.

It is not only that by using a we have accepted the phase change, it is that we have used precisely the Lorentz transformation and the proper value a (unique and of convergence) to materialize (make physical) that phase change, to "freeze" the wave group and consider it to operate with it. To make physical that phase change is to establish internal cohesion forces stronger than those of dispersion, which forces them to maintain the form and travel as a whole, in the same way that a soap bubble maintains the form through surface tension, without which it would not be understood, the fact itself, which is so irrespective of our knowledge of this basis or how far off we are in our conjectures about it.

The fixation of the envelope is what nature has chosen to neutralise the forces of dispersion, to create matter and to give it form, regardless of whether we are able to notice its "surface tension" or to correctly imagine what it consists of. Further in this effort of imagination, we can think that nature does this by creating stationary wave packets, that is, by establishing boundaries at the ends of these packets, which in this case would be constructed by the process of symmetrisation whereby, forming a donut, one envelope would serve as a boundary for the other. If in addition, the distance of the extremes is that of the envelope itself in Equation (2), that is, the one that gives rise to size a, we would have that both waves would be authentically the same, in such a way that we can well consider that the wave overlaps reflected with the incident in each envelope or that each incident progresses (in a second identical cycle) and is added in the even envelope.

An assumption that we will have to model or develop, but which is based, like everything else, on the two formants, which make possible the construction of an initially static and self-sufficient physical system, a small universe from which it cannot escape or in which any attempt to do so (movement) does not represent a collapse, because it cannot occupy a different space and give rise to dispersion because it already occupies all of it: there is no difference between occupied and generated space but an internal advance that guarantees this and other dynamics that we will develop in future work.

We can see the phenomenon differently. When we are talking about wave functions we are talking about fields, that is, entities that support the development of the different variables, of which circumstantially we can know their value by applying certain operators, such as the Lagrangian of the system or the momentum operator. We can understand the creation of the particle, according to Equation (4), as a process of formation, which has a partial dissociation from the field associated with it, as a singularity therefore. In this case, the variables of the wave function undergo an evolution, and at some point the group of waves, which is governed by that function, becomes uncoupled from these variables by cancelling its wave phase with an inverse phase in the symmetrisation process. This is in essence the Lorentz transformation (4), as we have applied it, the conformation of a singularity of size a common to all x and all t, defined through x and t, and alien, however, to x and t. A transformation by which, in addition, another characteristic is acquired that is so closely related to the final singularisation of the particle as is the density of waves or wavenumber confined within it that we call mass. That singularisation, in this case, not only implies the definition of size and substance but the detachment of that space called size from the other generic space assigned to the spatial coordinate *x*, and this can be as much as creating the space, or said more specifically, a metric or possibility of dimensioning the space, that until that moment was only mathematical space and that from then on becomes physical space.

From there, there are two different spaces, two phases, two densities, inasmuch as the apparently local change implies the generalized creation of dense space, that is, of singularities with size, that enter into relations of size among them and substantiate the spatial dimension of phase Φ_1 on the basis of a phase Φ_0 in which there truly does not exist a real dimensionality of the dimension *x*. A phase Φ_0 that we could associate with the toroidal regions, which present themselves as "points" for phase Φ_1, created or configured on the external-discreet reference, but which, internally connected and undifferentiated, could be understood as an underlying grid of reference, another density, another universe. Phases Φ_0 and Φ_1 which, as I said and we see, have a differentiated space of development associated with them, a different field of speeds.

This also leads us to the idea that all the processes that we perceive are perceived in our phase, in material Φ_1, and that the luminous processes are the representation in our phase of characteristic processes of a different phase that are presented to us through the same as immaterial. There may be some phenomenology that is represented to us in our phase as it is and others that, to become evident, adapt to it. We have experience of what is represented in our phase, even if it does not belong to it, and equations for that experience, but we do not know of the other phases and neither what happens in the interface.

The absence of that knowledge is not problematic when we can reduce what we know or want to know to what happens in the context of a single phase (to the aforementioned equations), as is the case with electromagnetic interaction in our phase, but it is problematic when two phases are involved, and consequently the interface, in that it leads us, whether we are aware of it or not, to the erroneous interpretation of some phenomenologies, including the one concerning the predictable dispersive character of the wave group in our phase as opposed to the non-dispersive, or bound, character developed in the adimensional or dimensional interior of another species (phase) of the toroid.

Although it is true that knowledge limited to one phase is not problematic, it is also true that it involves a conceptual error when we treat different species undifferentiated, as we do with light when we include it by equations in our physical space (phase) without truly being. The reality is that material space is a singularity for the physical space of light, and for this reason, this drastic change regarding materiality, and the space of light is a singularity for material space, and for this reason, we perceive it to be an unattainable speed, singular in relation to the set of relative speeds with which we perceive ourselves in the material world. Attributes that are perceived in this way exclusively by virtue of our singularity, from our perception, since things are not something in themselves, but observed information, and neither does this materiality exist from the physical space of light nor a reciprocal "speed of light" from the same. In other words, the things of the universe are informational elements that some of us read in one way and others in another, physics being the set of those elements that we all read in the same way: one physics. Consequently, the materiality of the universe, that of wave groups as their functional elements, is a perception that is set in motion for us from a click to a range of vibration or densification because we as observers participate in that same range of densification, that is, we attend to that click, attending or not to others by virtue of the relation of inclusion or permeability. To say this without the equations presented may sound like an ancestral hunch. But with them, and in particular with Equation (5), which relates the different forms of materiality to the successive phases that have been overcome, the question changes, although it should be treated, and will be in the future (where we will talk of SWP and relativity), with more rigour.

5. The Third Term of the ETE

We can perform a similar treatment on the wave part (5c) of the energetic expression for $\Phi_\nu = \left[\Delta k\left(a\nu\right)\right] = \left[\mathrm{T}\nu\right]$:

$$\begin{aligned}\bar{E}_\omega &= A^2\int \zeta^\omega\left(\upsilon\right)\mathrm{d}\upsilon = A^2\int \zeta_\omega\left(\upsilon\right)\mathrm{d}\upsilon \\ &= \left(\frac{\hbar\omega b}{\pi a^2}\right)c\int \frac{\cos\left[\Phi_\nu\right]}{\left(1-\nu^2\right)^{1/2}\nu}\mathrm{d}\nu \\ &= \left(\frac{\hbar\omega b}{\pi a^2}\right)c\int \frac{\cos\left[\mathrm{T}\nu\right]}{\left(1-\nu^2\right)^{1/2}\nu}\mathrm{d}\nu.\end{aligned} \quad (36)$$

The analysis of the integration limits is in this case even more relevant since the original state is necessarily the electromagnetic one, which in a way would seem to fix the limits of integration and the path. A path which in itself, and over and above all the appreciations we may wish to make (and those concerning the second term), is already defined through the change of variable which, nevertheless (and as we have already mentioned) we could always accommodate if necessary, by the weight of the physical criteria, by using Equation (1a) instead of Equation (1b), which changes the sign of Equation (5c) while leaving the other terms unchanged. This is why we have to validate the path taken by these physical criteria.

With regard to the limits, and in a first assessment of these criteria, while it is true that the original state is the electromagnetic one, with $\upsilon = c$, it is also true that it is a non-integrable state ($\nu = 0$) and that it cannot evolve towards (or from) $\upsilon \neq c$ by its very nature. This shows that in the process this energy would first have to lose its luminous character or, to put it better, the ubiquity of that character (as in the interior of the toroid), a matter that could be related to the constitution of a quasi-corpuscular element, that is, with the discrete (photonic) version of the electromagnetic energy. A version that, in line with what has been developed, could be given by the initial formation of the single or individual wave packets with group velocities of a value very similar to the phase velocity *c*, which is not a process ascribed to our energy integral but to that of the formation of the wave packet or equivalent light pulse, already mentioned, prior to and necessary for discretising the system and making it capable of holding information (optical signal). Individual wave packets that, then yes, have development through the symmetrisation process, that, then yes, can be applied with its energetic power where it corresponds, in such a way that the same as the term (5b) evolves in a way to absorb energy up to a certain value $\upsilon \approx c$, the term (5c) evolves analogously for the transfer of that energy, as its source, to a value capable of supporting the energy needs of Equation (5b) and of a kinetic differential if any.

Concerning the path, we can assume two formulas with identical results (same final balance). Either the electromagnetic process in the interval $]c, 0]$ is the representation of a different phase (the wave phase) of the corpuscular formation, according to Equation (9), with global zero energy balance ($\bar{E}_\omega = \bar{E}_f$), or the electromagnetic process plus the corpuscular formation is a simple energetic transit in the same interval $[0, c[$ until the process concludes, with zero energy balance also, ($\bar{E}_\omega + \bar{E}_f = 0$), but in the phase itself, as in Equation (5). Always on the premise, compared to other options, that it will be the ability to yield formation energy (the sign ± of the same), shown in the equation itself, which will finally resolve any dilemma.

That is, we can understand that there is an essentially wave-like process, similar to one (5a) takes place, an inverse path between an inertial energy value (not consolidated into a particle) and a final particle $m_i \approx 0$ (which we do not detect in the processes and which, however, could explain some of them, such as the occurrence of neutrinos in decays), or we can understand that Equation (5), as an expression of the process, does not make a double representation and that, in effect, it is carried out within the same process (and phase) and with the same final limit (as we said, the same and only limit defined in the change of variable), without prejudice to the fact that the final result (the particle) constitutes another phase, the same one in which the term (5a) then unfolds.

Leaving behind the previous schematism, and beyond all interpretations, we see that in Equation (5c) we have, as in Equation (5b), a dimensionless rational integral which, although it does not come from a recognisable primitive, is numerically resolvable over the whole interval described except at the points where the integrand itself is divergent ($\nu = 0$). Consequently, to begin with, and analogously to what was developed previously in Equation (28) and Equation (29), we have:

$$\bar{E}_\omega = \left(\frac{\hbar \omega b}{\pi a^2}\right) c \int_{\nu=1}^{\nu>0} \frac{\cos[\mathrm{T}\nu]}{\left(1-\nu^2\right)^{1/2} \nu} \mathrm{d}\nu = \left(\frac{\hbar \omega b}{\pi a^2}\right)\left(\beta_-^\omega\right) \times c \cong -\left(\frac{\hbar \tilde{\omega} b}{\pi a^2}\right) c. \tag{37}$$

Value $-\beta_-^\omega = \beta_+^\omega$ is assimilated by the variable ω as $\tilde{\omega}$

In this case, we see that we have a coefficient that is not accompanied by c^2, making it clear that this is not a massive factor that can be compared to another massive factor, as we did in Equation (33).

However, we can directly equate the energies in this case, the corpuscular and non-corpuscular, for the same purpose, considering that one comes from the other and that the kinetic energy is zero,

$$\begin{aligned} &\bar{E}_\omega + \bar{E}_f = 0 \Rightarrow \bar{E}_f = -\bar{E}_\omega \Rightarrow \left(\frac{\hbar \Delta \tilde{k} b}{2\pi a^2}\right) c^2 = \left(\frac{\hbar \tilde{\omega} b}{\pi a^2}\right) c \\ &\Rightarrow \frac{\Delta \tilde{k}}{2} c = \tilde{\omega} \Rightarrow \frac{(2\pi \Delta \kappa)\alpha_+^k}{2} c = \frac{\pi \alpha_+^k}{\Delta \lambda} c = \tilde{\omega}, \end{aligned} \tag{38}$$

where the relationship between both is shown and, in particular, that between the initial energy charge of the electromagnetic wave through $\tilde{\omega}$, and the final width of the group of waves, which has to do with its wave density, that is, with the mass. A wave density which, according to the last equivalence, is present in the final situation of the wave term, highlighting that we are dealing with a wave packet, which allows us to put the expression how:

$$\begin{aligned} &\frac{\pi \alpha_+^k}{\Delta \lambda} c = \tilde{\omega} = (2\pi \nu) \beta_+^\omega \overset{\nu = c/\lambda_0}{=} \frac{2\pi \beta_+^\omega}{\lambda_0} c \\ &\Rightarrow \frac{\Delta \lambda}{\alpha_+^k} = \frac{\Delta x}{\alpha_+^k} = \frac{\lambda_0}{2\beta_+^\omega} \Rightarrow \lambda_0 = \frac{2\beta_+^\omega \Delta x}{\alpha_+^k}, \end{aligned} \tag{39}$$

where it is evident the transition between the densification of the wave packet before and after the SWP. Thus, by means of λ_0 the energy is fixed in Equation (37) to the minimum necessary to conform the particle of size *a*, being (assumed to be the only source of energy) of any higher energy value ($\lambda_1 < \lambda_0 \to \hbar w > \hbar \omega$), which would give rise to a surplus of energy convertible into kinetic energy for the newly created particle, as already noted. A variable λ_0 which would give rise to $k_0 = 2\pi/\lambda_0$, and which would allow us to obtain the coherence length l_0 of the pulse (see C. 20.3 of [3]).

It is not difficult to find, through this Equation (39) and Equation (34), the relationship [analogous to Equation (34)] between finite wavelength and particle size:

$$a = \frac{\lambda_0}{2\pi \beta_+^\omega}, \tag{40}$$

In which, in this case, two of the parameters are unknown, which would require a resolution carried out in an indirect way through the approximate value of β_+^ω, according to the definition itself (integral), and the value α_+^k obtained analytically (equations). Irrelevant to the matter at hand but nevertheless allows us to check the biunivocal relation of α_+^w and β_+^w for the value *a* for a type of particle or minimum energy required for a value λ_0, according to Equation (39), which is none other than that which exists between the integral functions of Equation (5b) and Equation (5c), as evidenced in the representation of the latter for $T = 1$ and $T = 100$ (see **Figure 3**), and its comparison with the previous one (**Figure 2**).

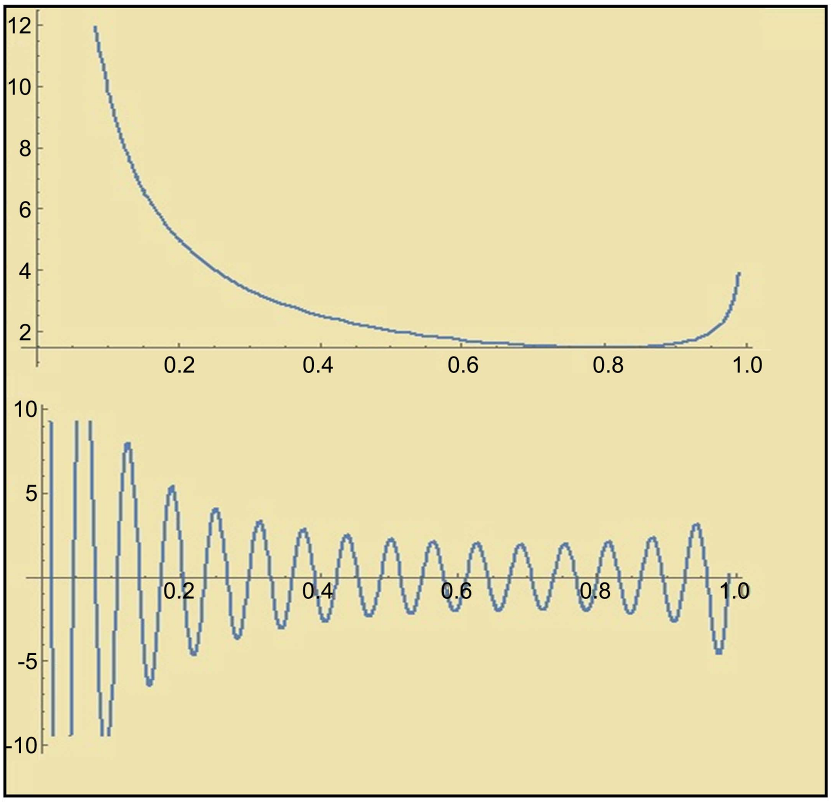

Figure 3. Function $-\beta_{-}^{w} = \beta_{+}^{w}$ for $-\bar{E}_{\omega}$.

Which highlights a fairly similar behaviour of the variable and shows that both functions are linked in their evolution or that the energy balance is linked with them, in that the increasing energy of one (the energy increase) corresponds to the decreasing energy (the energy decrease) of the other, from which we can deduce that it is, as we have been maintaining, a process of energy transfer. This can be clearly differentiated from the process of energy conversion or reconfiguration carried out in the formation of a pulse in which the initial and final objects have the same luminous nature, and we cannot speak of a phase change in this case because there is no change of materiality or densification, such as that produced by the SWP.

6. Summary and Discussion

This paper is part of a series, in which first the underlying equation was presented (first block [1]), and now, after presenting some direct results from it (second block [1]), it is being interpreted physically and will be interpreted further, drawing as faithfully as possible all the physics derived from it on the basis of a more detailed analysis of the phase factor for each of the particle classes, and of the symmetrisation process, which has taken on the role of a mere tool but is the foundation, in order to reach conclusions on questions that the scientific inertia does not reach, as well as correcting others that it does or that it discards.

This scientific inertia uses (is due to the use of) physical models that work well structurally but are nevertheless functionally and essentially flawed, as a consequence of being formalisms or high-level languages. High-level formalisms, such as QFT, are representations of reality because they are themselves formal representations of a given mathematical space or of the vector groups on which they rely, *i.e.* a schema. A schema of the reality, but not the reality.

Schemes cannot talk about what lies beneath the scheme, that which the scheme itself dispenses with, which is why it cannot talk about what the mass essentially is (as we do here) or can only talk about it as something that creates an operator (of creation), but without being able to say what it is, without satisfying our minimal intuitive requirements or desire to know (what things are in themselves), highlighting not only the weakness of the models but also the weakness of our demands about them.

The interpretation of reality must coincide with the intuitive expression of reality, which we must only require to be physically representable. This is why we need a first-layer, low-level formalism that connects us directly to the hardware (to the reality), such as the one we sketch in our proposal, which provides essential results precisely because of this.

An intuitive expression that arises from the necessity to meet or find a universe structured in a certain way, which must necessarily also be an internally living form, *i.e.* with a first and permanent cause: here we have not only reached the intimate constitution of elementary matter, *i.e.* the expression of it as a density of waves, but we have also defined the geometrical form of this singularity and established that, according to the logic of its formation and the expressions, it must coincide with that of a toroid, which is also not rigid but fluctuating through the phase factor $\sin[\Phi]$ and its dynamic dimensions (υ_h), which is its pulse, its original vital rhythm, the uninterrupted connection with the dimensionless and creative universe, and its passport of return to it, the one that occurs in annihilations and generational changes. The probability (or non-definition) and fluctuation of quantum states are part of that pulse.

We have found through our development the ETE, which achieves different credentials from the similarity of its terms with those known from corpuscular physics, being the kinetic energy term the one that certifies this comparison and legitimises the use of the Lorentz transformation as a singular, and not relative, change of variables in this development.

The kinetic term has a mass coefficient formed by wave parameters and a wave factor which, not appearing in the corpuscular expression, we understand as a phase factor whose importance we have shown in the second block of [1] for the structure of the fermions of the SM through the $\sin[\Phi]=0$ condition, which is the one that allows the energy transmutation or conversion of the kinetic energy into matter. A condition on the phase factor that involves the dynamic state of the particle itself registered in it, which allows us to affirm that this register is not a chimera but something functional. And not only for phase changes but for all those processes in which some kind of wave-particle duality is manifested, which allows us to identify this phase factor with the matter wave, without the need to make any conjecture, connatural, or aprioristic if we think that it is a wave factor associated with the mass of the kinetic energy. Something that has also proved providential with regard to quantum entanglement.

Something similar happens with the mass. The identification of the mass coefficient with the mass is immediate and everything else is a simple opportunity to obtain information from previously unidentified and therefore unassessed constituents.

We can say that the only accidental element is the variable t that we have been dragging along in the process, like [T], until we fixed it or associated it with a to become $\upsilon_\hbar$. However, what at first sight seemed somewhat awkward has turned out to be highly understandable and justifiable, as well as fulfilling the requirement of dimensional homogeneity. The fact that we had this variable out of place was nothing more than a consequence of not having, a priori, the connection that we established later. That is to say, it was obviously necessary to associate it with another variable but we did not initially know which one, and we did not know this until we were able to base the connection established for t (together with the other t) on the two-dimensional form a^2 to reach the new variable $\upsilon_\hbar^2$, as the only possible one (and with a physical sense), as we have done in Equation (19).

A variable $\upsilon_\hbar^2$ as the only possible one, which has a correspondence with c^2, giving both c^2 and $\upsilon_\hbar^2$ the functional utility already developed, which in itself presents no objection and, on the contrary, unravels the dimensional relation existing between the two states of densification of energy, which we can express by means of the proportionality derived from Equation (20):

$$\frac{E_r}{c^2}=\frac{E_\hbar}{\upsilon_\hbar^2}\Omega\propto\frac{E_r}{\upsilon_\hbar^2\times a}\Rightarrow\upsilon_\hbar^2\times a\propto c^2, \tag{41}$$

which explains in schematic form why something two-dimensional (two formants) gives rise to something three-dimensional without losing its vibrational nature in those two dimensions, from where it can regain it in its entirety.

This allows us and would have allowed us initially, had we started from these premises, to write m_r in Equation (5) in a more explicit and, if we wish, general form, by means of the result reached in Equation (19), which, well defined for the kinetic term, serves as a reference for the others (although, as we see, they may be subject to simplifications):

$$\begin{aligned}\bar{E}&=A^2\int\zeta^m(\upsilon)\mathrm{d}\upsilon+\zeta^\omega(\upsilon)\mathrm{d}\upsilon\\&=A^2\int\left(\zeta_k(\upsilon)+\zeta_f(\upsilon)+\zeta_\omega(\upsilon)\right)\mathrm{d}\upsilon=\bar{E}_k+\bar{E}_f+\bar{E}_\omega\\&=\left(\frac{\Delta\hbar\!\!\!\lambda}{\pi^2 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2}\sin[\Phi]\int_{\upsilon_o}^{\upsilon_f}\frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon \qquad \text{(a)}\\&\quad-\frac{a}{2\Delta\hbar\!\!\!\lambda}\left(\frac{\Delta\hbar\!\!\!\lambda}{\pi^2 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2}c^2\int\frac{\cos[\Phi_\nu]}{\nu}\mathrm{d}\nu \qquad \text{(b)}\\&\quad+\omega a\left(\frac{\Delta\hbar\!\!\!\lambda}{\pi^2 a}\right)\frac{E_\hbar}{\upsilon_\hbar^2}c\int\frac{\cos[\Phi_\nu]}{\left(1-\nu^2\right)^{1/2}\nu}\mathrm{d}\nu. \qquad \text{(c)}\end{aligned} \tag{42}$$

An expression that we can put in a more clarified form if we now recover Ω in m_r and (disregarding those feasible simplifications) take into account Equation (39), that is $\omega = 2\pi\nu = 2\pi c/\lambda_0$, which allows us to express (42c) as an energy term over c^2, as well as the previous one:

$$\begin{aligned} \bar{E} &= A^2 \int \zeta^m(\upsilon)\mathrm{d}\upsilon + \zeta^\omega(\upsilon)\mathrm{d}\upsilon \\ &= A^2 \int \left(\zeta_k(\upsilon) + \zeta_f(\upsilon) + \zeta_\omega(\upsilon)\right)\mathrm{d}\upsilon = \bar{E}_k + \bar{E}_f + \bar{E}_\omega \\ &= \left(\Omega \frac{E_\hbar}{\upsilon_\hbar^2}\right)\sin[\Phi] \int_{\upsilon_o}^{\upsilon_f} \frac{\upsilon}{\gamma^{-3}}\mathrm{d}\upsilon \qquad \text{(a)} \\ &\quad - \frac{a}{2\Delta\tilde{\lambda}}\left(\Omega \frac{E_\hbar}{\upsilon_\hbar^2}\right)c^2 \int \frac{\cos[\Phi_\nu]}{\nu}\mathrm{d}\nu \qquad \text{(b)} \\ &\quad + \frac{2\pi a}{\lambda_0}\left(\Omega \frac{E_\hbar}{\upsilon_\hbar^2}\right)c^2 \int \frac{\cos[\Phi_\nu]}{(1-\nu^2)^{1/2}\nu}\mathrm{d}\nu. \qquad \text{(c)} \end{aligned} \tag{43}$$

In which, moreover, the suppression of a spatial dimension of the other terms with respect to the first one (externally three-dimensional) is more clearly seen through the double dimensionality of its initial factor. Three-dimensionality that Equation (43b) recovers through the integral, according to Equation (33):

$$\alpha_+^k = \frac{2\Delta\tilde{\lambda}}{a}, \tag{44}$$

Contrary to Equation (43c), for which the integral does not densify, being for this reason that originally only one free A appears, and not B, characteristic of the possibilities of energy expansion of the densified inertial mass (rest and kinetic).

In the same way that we can express over c^2 the term (43a) of ETE, after solving the integral [according to Equation (8b)], evidencing their common nature more clearly, and their simplicity if we definitively rescue the massive term m_r, and we return to the starting variable Δk and the correlated variable Δk_0. That is:

$$\begin{aligned} \bar{E} &= A^2 \int \zeta^m(\upsilon)\mathrm{d}\upsilon + \zeta^\omega(\upsilon)\mathrm{d}\upsilon \\ &= A^2 \int \left(\zeta_k(\upsilon) + \zeta_f(\upsilon) + \zeta_\omega(\upsilon)\right)\mathrm{d}\upsilon = \bar{E}_k + \bar{E}_f + \bar{E}_\omega \\ &= (\gamma - 1) m_r c^2 \sin[\Phi] \qquad \text{(a)} \\ &\quad - \left(\frac{a\Delta k}{2}\right) m_r c^2 \int \frac{\cos[\Phi_\nu]}{\nu}\mathrm{d}\nu \qquad \text{(b)} \\ &\quad + (ak_0) m_r c^2 \int \frac{\cos[\Phi_\nu]}{(1-\nu^2)^{1/2}\nu}\mathrm{d}\nu. \qquad \text{(c)} \end{aligned} \tag{45}$$

ETE which can be made even simpler by referring it to E_r and replacing the other integrals by their symbolic values:

$$\begin{aligned} \bar{E} &= \bar{E}_k + \bar{E}_f + \bar{E}_\omega \\ &= E_r(\gamma - 1)\sin[\Phi] + E_r\left(\frac{a\Delta k}{2}\right)\left(\alpha_+^k\right) + 2E_r\left(\frac{ak_0}{2}\right)\left(\beta_-^\omega\right) \end{aligned} \tag{46}$$

In which we have separated $\overline{E}_{\omega}$ into its two wave formants, which have the same form as $\overline{E}_{f}$ (to which it may eventually give rise or from which it may start), it becomes clear, as we have already seen in another form in Equation (39), that $\Delta k\left(\alpha_{+}^{k}\right)=2k_{0}\left(\beta_{-}^{\omega}\right)$.

Having said that, just as the objective of [1] was one, but we advanced some questions that we have dealt with here, the objective here has been one mainly, the study of the equation, so that what has not been that has been a mere advance of something that we will deal with, which has not pretended to be rigorous but contextual. It will therefore be in other works where we will address the real meaning of the phase, of the velocity field, treated in relation to the wave phase and relativity, and where we quantify the variables used for each of the families and take advantage of the process integrals [in a particular way to Equation (35)] of which we have so far only assessed their similarity and correspondence in the energy transmutation process.

Conflicts of Interest

The author declares no conflict of interest.

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