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INTRODUCTION

As is well known, Einstein, having introduced the Special Theory of Relativity in 1905, proceeded to deny the existence of the 19th century luminiferous ether both in his technical papers as well as in his articles for the general public. The fact has occasioned that among the general public he has acquired the reputation of being the destroyer of the ether concept in general.

Such an opinion is today propagated in textbooks, encyclopedias and scientific reviews. Therefore most physicists and philosophers are convinced that Einstein has removed the notion of the ether from physics for ever. This opinion, however, is not precisely correct because since 1916 the notion of the ether has found in Einstein's Relativity Theory a new and interesting application and development.

The main aim of this paper is to present a short historical outline of Einstein's new relativistic ether and to discuss its physical meaning and updated applications.

A SHORT HISTORICAL OUTLINE OF EINSTEIN'S IDEAS CONCERNING ETHER

In 1894 (or 1895) Einstein, being 15 (or 16) years old, wrote his first "scientific" paper (which he never published) entitled "Über die Untersuchung des Ätherzustandes im magnetischen Felde."[1] At that time Einstein believed in the existence of a stationary quasi-rigid luminiferous ether. He regarded it as an elastic medium and wondered in particular[2] how "the three components of elasticity affect the velocity of an ether wave" which is generated when the electric current is turned on.

As ETH student Einstein wanted to construct an apparatus which would accurately measure the earth's movement against the ether.[2] In 1901 he wrote a letter to his friend Grossman in which he told him : "A new and considerable simpler method for investigating the motion of matter relative to the lightether

has occurred to me."[2] In his speech at Kyoto University Einstein informs us about this method:

I tried to find the clear experimental evidence for the flow of the ether in the literature of physics, but in vain. Then I myself wanted to verify the flow of the ether with respect to the earth, in other words, the motion of the earth. When I first thought about this problem, I did not doubt the existence of the ether or the motion of the earth through it. I thought of the following experiment using two thermocouples: Set up mirrors so that the light from a single source is to be reflected in two different directions, one parallel to the motion of the earth and the other antiparallel. If we assume that there is an energy difference between the two reflected beams, we can measure the difference in the generated heat using two thermocouples. Although the idea of this experiment is very similar to that of Michelson, I did not put this experiment to a test. While I was thinking of this problem in my student years, I came to know the strange result of Michelson's experiment. Soon I came to the conclusion that our idea about the motion of the earth with respect to the ether is incorrect, if we admit Michelson's null result as a fact. This was the first path which led me to the special theory of relativity.[3]

In 1905, having formulated the special relativity theory, Einstein began to deny the existence of the stationary luminiferous ether. He considered it as "superflous"[4] and wholly useless[5-7] because according to the relativity principle an absolute space at absolute rest does not exist and because the electromagnetic fields have to be regarded as independent realities which are not states of a medium. Einstein maintained even that: "the ether in the old sense does not exist"[8] and propagated this opinion not only in the scientific reviews but also in newspapers e.g. in the *Vossische Zeitung*.[9]

The history of the new (relativistic) ether conception began in 1916 i.e. after the definitive formulation of the general relativity theory. The introduction of the new conception was provoked, in a certain sense, by H. A. Lorentz and Ph. Lenard.

Lorentz wrote a letter to Einstein in which he maintained that the general theory of relativity admits of a stationary ether hypothesis. In reply Einstein introduced a new definition of the ether:

$$\text{"state } g_{\mu\nu} = \text{ Aether"}$$

He wrote to Lorentz on 17 June 1916:

I agree with you that the general relativity theory admits of an ether hypothesis as does the special relativity theory. But this new ether theory would not violate the principle of relativity. The reason is that the state $g_{\mu\nu}$ = Aether is not that of a rigid body in an independent state of motion, but a state of motion which is a function of position determined through the material phenomena.[10]

As we see the physical space (connected closely with time) described by the symmetrical tensor $g_{\mu\nu}(g_{\mu\nu} = g_{\nu\mu})$ was considered by Einstein as a relativistic ether. Einstein did not publish his new idea either in 1916 or 1917. The first appearance in print of the new conception was provoked by Ph. Lenard. In 1917 Lenard published a paper against Einstein's relativity theory entitled "Über Relativitätsprinzip, Äther, Gravitation."[11] In this paper he maintained that in the general relativity the disqualified ether (disqualified by the relativity theory) came back under a changed name "Space." In reply Einstein wrote an essay

entitled "Dialog über Einwände gegen die Relativitätstheorie"[8] in which he published the above presented new definition of the ether. This definition will be called by Einstein in the famous Einstein—Lenard discussion concerning ether and relativity theory in Bad Naheim (1920) : "eine neuartige Definition für den Begriff Äther."[12]

Einstein introduced three new models of the ether:

(1) The first one is that of the special relativity theory. In the mathematical description of this ether the 10 components of the metrical tensor are constant $g_{\mu\nu} = \eta_{\mu\nu}(g_{11} = g_{22} = g_{33} = 1; g_{44} = -1$ and the other 6 components $= 0)$. The ether of the special theory of relativity is rigid and to a certain extent four-dimensional. It is infinite and flat. Its metric is pseudo-Euclidian.

(2) The second one is that of the general relativity theory. In the mathematical description of this ether the 10 components of the $g_{\mu\nu}$ tensor are no longer constant. The space states described by the tensor $g_{\mu\nu}$ can change not only from place to place, but also in time. The ether of the general relativity theory is no longer rigid and flat. Its metric is pseudo-Riemannian.

(3) The third one is that of the unitary relativistic field theory. In the mathematical description of this ether the symmetrical tensor $g_{\mu\nu}$ does no longer describe the ether in the complete way because the geometrical structure of it is more than Riemannian. New structure elements have to be introduced for a complete description of the ether because it has to determine not only the inertio-gravitational phenomena, but also the electromagnetic ones.

Summarizing we can say that since 1916 Einstein's physics of space-time became a physics of a new ether. Nevertheless, we must mention that after 1934 Einstein began to use the word "ether" less and less often, although he wrote still in 1938 : "This word ether has changed its meaning many times in the development of science [...]. Its story by no means finished is continued by relativity theory,"[13] and though he indicated still in 1954 that e.g. the : "rigid four-dimensional space of the special theory of relativity is to some extent a four-dimensional analogue of H. A. Lorentz's rigid three-dimensional ether."[14]

THE REAL PHYSICAL SPACE CONSTITUTES A RELATIVISTIC ETHER

According to Albert Einstein :

> [...] there is an important argument in favor of the hypothesis of the ether. To deny the existence of the ether means, in the last analysis, denying all physical properties to empty space.[15]

In Einstein's theory of relativity the three physical notions : "space" "ether" and "field" have found their complete unification through consequent identification.

> Physical space and the ether, are only different terms for the same things ; fields are physical states of space.[16]

ECE presents Einstein's original interpretation of the models of physical space constructed in his special and general relativity and in his unitary field theory. It constitutes a gradual conceptual activation, dynamization and materialization of the physical space. According to *ECE,* in its most developed form, the physical space closely connected with time is not a passive and static container of events and not physically indifferent or neutral arena of physical phenomena but an active and dynamic field which determines the inertio-gravitational, electromagnetic and other processes and produces even elementary particles. The real physical space, as an active field of this kind, possesses energy and therefore mass as well and that is why it is material. It constitutes an active matter *sui generis* for which the term "ether" is the best name.

The Activation of the Physical Space

It has "seemed utterly absurd to the physicists of the nineteenth century to attribute physical functions or states to space itself."[16] It is not so in Einstein's theory of relativity, the physical space plays there a real active part in physical processes. When Einstein speaks about ether :

> [...] we are dealing with those things thought as physically real which alongside the ponderable matter composed of elementary particles, play an important part in the causal nexus studied in physics.[17]

The "physically real things" mentioned here are the "real qualities of space" and that is why Einstein continues in the same paper :

> Instead of speaking about ether, somebody might just as well speak about the 'physical qualities of space'.[17]

According to Einstein's new conception, it is impossible to formulate a complete physical theory without an (at least latent) ether hypothesis, because every complete physical theory must take into consideration the real properties of the physical space i.e. the *Milieu-Einflüsse.*[17] Somebody might not use the word "ether" but has to recognize that the physical space has real physical properties which play an active part in physical happening and therefore Einstein maintains :

> The ether hypothesis was bound always to play a part even if it was mostly a latent one at first in the thinking of physicists.[15]

According to *ECE* the absolute (i.e. independent from time and matter) space of Newton, because of its active "inertia-determining function"[16] constitutes one of the models of the ether.[17] In this model :

[...] space was conceived as absolute in other sense also ; its inertia determining effect was conceived as autonomous i.e. not to be influenced by any physical circumstances whatever ; it affected masses but nothing affected it.[16]

Einstein's special and general relativity and his unitary field theory, as it was mentioned already, have their own models of ether identified with the physical space.

(a) In Einstein' special relativity model, where the ether became "to a certain extent four-dimensional"[17](because of the relativity of simultaneity) the physical space accomplishes the active function "determining the inertial behaviour of a test body introduced into it"[14] and has the physical property of transmitting electromagnetic waves"[13] but "it no longer stands for a medium built up of particles"[14] or points[17] and is no longer regarded as an immobile or stationary medium as it was supposed in the Newtonian model of the physical space and in Lorentz's conception of the ether.

The special principle of relativity forbids us to regard the ether as composed of particles the movement of which can be followed out through time, but the theory is not incompatible with the ether hypothesis as such. Only we must take care not to ascribe a state of motion to the ether.[15]

The whole difference the special theory of relativity made in our conception of the ether lay in this, that it divested the (Lorentz's) ether of its last mechanical quality namely immobility.[15]

According to the special relativity, the ether remains still absolute because its influence on the inertia of bodies and on the propagation of light is conceived as independent of every kind of physical influence.[17]

(b) The ether of Einstein's general relativity is no longer absolute in the above mentioned sense because "it not only conditions the behaviour of inert masses but is also conditioned, as regarded its state by them."[15]

Einstein's general relativity is incomprehensible without an active ether.

According to the general relativity space is endowed with physical qualities ; in this sense, therefore, an ether exists. In accordance with the general theory of relativity space without an ether is inconceivable. For in such a space there would not only be no propagation of light, but no possibility of existence of scales and clocks, and therefore no spatio-temporal distances in the physical sense. But this ether must not be thought of as endowed with the properties characteristic of ponderable media, as composed of particles the motion of which can be followed; nor may the concept of motion be applied to it.[15]

The general relativity ether manifests its activity through its function determining the inertio-gravitational behaviour of the bodies and through the creation of elementary particles. A test body or particle which is only under the influence of the physical space is at rest or follows a geodetic (curved or straight) respectively in curved or locally flat spaces of reference.

Einstein has at first occasionally noted the possibility that material particles might be considered as singularities of the material field but subsequently he arrived at the conviction that this point of view could not be accepted at all. "For

a singularity brings so much arbitrariness into the theory that it actually nullifies its laws."[18] He made therefore attempts to find solutions of general relativity field equations free of singularities which might "be interpreted as presenting corpuscules."[19] Together with Rosen, he found such solutions of the centrally symmetrical gravitational field equations for both the neutral and for the electrical particles. Having found them he repeated his opinion expressed in 1924[17] that: "The neutral, as well the electrical particle is a portion of space,"[18] material space of course.

(c) In Einstein's general relativity (as in his special relativity) the electromagnetic field appears still as something which "fills space"[14] i.e. as something which does not belong to the structure of the physical space described by the metrical tensor $g_{\mu\nu}$. Since the real physical space was regarded by Einstein as the "fundamental" or "total field"[20] of all physical actions and not only of the inertio-gravitational one, he began to look for "a theory of the continuum in which a new structural element appears side by side with the metric such that it forms a single whole together with the metric."[14] Thus the formation of an unitary field theory became the main aim of Einstein's research programme.

He often emphasized that the pseudo-Riemannian space-time described by the tensor $g_{\mu\nu}$ does not constitue a complete description of the physical space connected with time. He made several attempts to generalize it e.g. through enriching "Riemannian space by adding the relation of direction or parallelism."[16] He was even convinced that he "found the most natural form for this generalisation"[14] in his "theory of unsymmetrical field"[21] (which he considered as his longtime sought unitary field theory) which unifies in his opinion the gravitational and electromagnetic interactions.

The activity of the ether described by Einstein's unitary field theory is richer than that described by Einstein's general relativity because it includes also the electromagnetic interactions, but today Einstein's unitary field theory is considered as unsatisfactory.

Dynamization of the Physical Space

In the Newtonian physics the physical space was regarded by physicists as a changeless reality. "Space was still for them, a rigid homogeneous something incapable of changing or assuming various states."[16] In Einstein's theory of relativity the physical space is no longer an immutable physically indifferent container entirely foreign to modifications but a dynamic changing in time medium.

(a) In Einstein's special relativity however, the ether is still "rigid,"

(The fourdimensional space of special theory of relativity is just as rigid and absolute as Newton's space.[16])

but the fusion of space and time in Einstein's special relativity : "has to be characterized as dynamization of space"[22] as it has been indicated e.g. by M. Čapek, because the physical space is no longer timeless. In Newtonian physics :

> [...] the true reality of space is timeless, change and succession belong merely to the physical processes, not to the space as such[22]

The fusion of time and space means an "incorporation of space into the physical becoming."[22]

(b and c) In Einstein's general relativity and especially in his unitary field theory we are no longer dealing with the traditional distinction between an immutable and static spatial container and its concrete and changing content.

> Space as opposed to 'what fills space' [...] has no separate existence.[14]

For instance, in general relativity it is meaningless to speak about the gravitational field as being located in space when the whole reality of this field is reduced to the modifications of the non-Euclidian spatio-temporal medium. The pseudo-Riemannian space-time with its curvature varying not only from place to place, but even in time, and in particular the idea of expanding and contracting space whose radius of curvature is continuously changing and also the real vibrating and waving of the mentioned spatio-temporal medium show the "nonrigidity" and the dynamic nature of Einstein's relativistic ether.

The idea of "nonrigid" and active physical space has been already introduced by Riemann.[23] According to Einstein's relation, we owe to Riemann :

> [...] a new conception of space in which space was deprived of its rigidity and in which its power to take part in physical events was recognized as possible.[16]

Materialization of the Physical Space

On the basis of the principle of equivalence of energy and mass (formulated already in the special relativity) Einstein arrived at the following conclusions :

(a) The real physical space (even though it was empty) as an active field possessing energy (and therefore mass as well) constitues an active matter *sui generis* i.e. an ether.

(b) There is no a qualitative difference between the material physical space and the ponderable matter ccmposed of particles.

(c) The formulation of a consequent unitary field theory, where the material physical space constitutes the primary matter producing the secondary one i.e. the elementary particles, must be possible.

> The division into matter and field is after the recognition of equivalence of mass and energy something artificial [...]. Matter is where the concentration of energy is great, field where the concentration of energy is small. But if this is the case, then the difference between matter and field is

a quantitative rather than a qualitative one. There is no sense in regarding matter and field as two qualities different from each other. There would be no place in our new physics for both field and matter field being the only reality.[13]

The mentioned "new physics" is the unitary field theory the formulation of which became Einstein's main research programme. According to this programme, the elementary particles have to be regarded as born in field and from field or in ether and from ether or also in space and from space. For, as we know, in Einstein's theory of relativity "field", "ether" and "space" are synonyms and they have to be conceived as the primary reality.

The strange conclusion to which we have come is this—that now it appears that space will have to be regarded as a primary thing and that matter is derived from it, so to speak, as a secondary result. Space is now turning around and eating up matter. We have always regarded matter as a primary thing and space as a secondary result. Space is now having its revenge, so to speak, and is eating up matter. But that is still a pious wish.[24]

As we see, in 1930, the formulation of a unitary field theory was Einstein's pious wish. In an other paper, written also in 1930, Einstein emphasized that the material physical space became for him the unique carrier of reality (*alleiniger Träger der Realität*)[25].

The real is conceived as a four-dimensional continuum with a unitary structure of a definite kind (metric and direction). The laws are differential equations, which the structure mentioned satisfies, namely, the fields which appear as gravitation and electromagnetism. The material particles are positions of high density without singularity.

We may summarize in symbolical language. Space, brought to light by the corporeal object, made a physical reality by Newton, has in the last few decades swallowed ether and time and seems about to swallow also field and the corpuscles, so that it remains as the sole carrier of reality[25].

EINSTEIN'S RELATIVISTIC ETHER CONSTITUTES AN ULTRA-REFERENTIAL FUNDAMENTAL REALITY

Einstein does not identify ether with the "reference spaces" (the number of which is infinite) composed of points and being at rest or motion with respect to each other. He identifies it with the "physical space as such" which is one and unique, not composed of points and to which the notion of motion in the mechanical sense cannot be applied at all. Einstein's relativistic ether *ERE* i.e. the physical space as such is something ultra-referential. It does not constitute a reference frame and has not a proper reference frame. If *ERE* had a proper reference frame it would have been at rest in it. *ERE* however is not a stationary ether.

The ultra-referential physical space cannot be conceived as composed of immobile points because an immobile point constitutes something totally relative. An immobile point of a reference space constitutes a set of collocal (or isotopic) events in this reference space. Since in Einstein's theory of relativity

collocality is something totally relative therefore the ultra-referential physical space is inconceivable as composed of immobile points. The Newton's absolute space is conceived as composed of immobile points, but not the ultra-referential Einstein's physical space as such.

Every point in the four-dimensional world has its world-line and therefore an extended entity composed of points (such as e.g. a reference space) can be presented in such a world as a set of world-lines. The extended *ERE,* of course, cannot be presented in such a manner.

In the language of Minkowski this is expresed as follows. Not every extended entity in the four-dimensional world can be regarded as composed of world-lines.[15]

The physical space as such is closely connected with time as such. It is important to note that the time as such is also an ultra-referential reality. There are infinite reference times intimately connected with their proper reference spaces but there is only one and unique ultra-referential time as such. The ultra-referential time is not composed of moments like the ultra-referential space is not composed of points. A moment constitutes a set of simultaneous events which belong to it. Since in the theory of relativity the simultaneity is a strictly relative thing, the ultra-referential time cannot be composed of moments. Nevertheless, the ultra-referential time is something "extended" composed of past, present and future. With respect to a freely chosen event considered as present there exists always a set of events which are absolutely past, and a set of events which are absolutely future. Every reference time is one of the possible orientations in the ultra-referential time. The ultra-referential time rends possible an infinite set of reference spaces.

The ultra-referential physical space is with respect to the reference spaces a more fundamental reality. The reference spaces are quasi-objects which move with respect to each other in the ultra-referential physical space but not with respect to it. The ultra-referential physical space rends possible the existence and motion of the reference spaces but it does not move at all in the mechanical sense.

On the other hand, the ultra-referential space is never passive or quiet. Einstein considers the nonatomically and nonmechanically conceived ether as the fundamental source of every physical activity, the creation of particles included. His presentation of this activity, (except the inertio-gravitational one), cannot be considered today as satisfactory. In this point Einstein's research programme cannot be regarded as accomplished in a definitive way.

Nowadays this programme, as it has been shown by Faddeev,[26] is continued in those hypothesis in which the elementary particles are presented as solitons on top of an active field. One of the reasons of Einstein's ill-succees was the lack of the introduction of the constant of Planck into the description of ether activity. In the creation of the elementary particles however, the elementary quantum of action must play a fundamental part.

EINSTEIN'S CONCEPTION OF THE ETHER UPDATED APPLICATIONS IN THE RELATIVISTIC WAVE MECHANICS

In 1923[27, 28] and 1924[29] L. de Broglie having introduced Planck's constant into Einstein's special relativity through the identy $mc^2 = h\nu$ which constitues the most basic assumption of his relativistic wave mechanics, discovered the relativistic waves called "waves of matter." This discovery, in our opinion, proves the real existence of *ERE* active excitation describable in the reference frames by wave functions. L. Broglie however, formulating his wave mechanics, did not use the notion of the ether at all,[30] but later, as his collaborator J.-P. Vigier testifies[31] took into consideration the possibility of an introduction of such a notion. He talked e.g. about the "deeper background of space."[31]

J.-P. Vigier, F. Halbwachs, F. Piperno, A. Kyprianidis, D. Sardelis et al.[32-34] developing de Broglie relativistic wave mechanics in the framework of so-called Stochastic Interpretation of Quantum Mechanics (SIQM) opposed to the Copenhagen Interpretation use Einstein's conception of the ether.[35] In SIQM this conception became however completed by Dirac's conception of the ether.[35] According to J.-P. Vigier et al. Einstein's relativistic ether i.e. the material $g_{\mu\nu}$-field is filled with Dirac's covariant etherlike vacuum[34] which constitutes a mixture of endowed with spin $J = 0, J = 1/2$ and $J = 1$ extended particles and antiparticles. Such a covariant mixture constitutes according to J.-P. Vigier et al. a background sea at absolute zero temperature on which the de Broglie real waves travel. Every particle (considered in SIQM as an extended entity) is surrounded by a real de Broglie wave. Since the Dirac's non empty vacuum constitutes a mixture of particles and antiparticles a de Broglie "pilot" quantum wave has to be regarded as a superluminal phase like collective drift and random motion on top of this non empty vacuum which implies subquantal fluctuations or jumps at velocity of light.

J.-P. Vigier emphasizes that Einstein's relativity theory is perfectly compatible with such an underlying relativistic stochastic ether model and that inherent to this model is Einstein's idea that quantum statistics reflects a real subquantal physical vacuum alive with fluctuations and randomness. The concept of a non empty vacuum has been revived not only to yield a foundation to the SIQM but also to explain causally possible nonlocal superluminal interactions resulting from Einstein—Podolski—Rosen paradox.[32]

J.-P. Vigier in his paper entitled "Non-Locality, Causality and Aether in Quantum Mechanics"[36] revisits Einstein's conception of the ether presented by Einstein in the essay "Über den Äther"[17] in the light of recent development in SIQM. He adds in this article to the usual $g_{\mu\nu}$ terms stochastic $\tilde{\delta}g_{\mu\nu}$ terms and describes space-time as a real subquantal covariant random medium which implies subquantal fluctuations. Thus the material space-time is considered by him as a fluctuating $\tilde{\delta}g_{\mu\nu}$-field.

Einstein's Relativistic Ether and the "Three-waves Hypothesis"

Einstein's conception of the ether is also used in the "three-waves hypothesis" (*TWH*) proposed by the author in 1978[37-39] also in the framework of de Broglie relativistic wave mechanics. The *TWH* constitutes an attempt to develop some ideas of Einstein's research programme concerning the elementary particles. In Einstein's research programme the elementary particles are conceived as "fields of particular kind" (*Felder besonderer Art*[17]) which constitute "particular states of space" (*besondere Raum-Zustände*[17]). Remaining in the framework of Einstein's programme and using de Broglie concept of "wave field" (*champ ondulatoire*[40,41]) the *TWH* presents the elementary particles as particular threefold wave fields (*TwFs*) which constitute particular states of the material physical space i.e. of Einstein's relativistic ether.

The *TwFs* can be observed from infinite reference frames. In the *TWH* they are studied, for the time being, only in the locally inertial reference frames i.e. where in the mathematical description, the components of the $g_{\mu\nu}$ tensor describing the gravitational potentials of the real physical space are constant and where the Christoffel symbols vanish i.e. where in the physical space the state of weightlessness governs. In such reference frames the physical quantities of the *TwFs* are varying according to the linear Lorentz transformation law and therefore the mathematical formalism of special relativity can be used.

A relativistic material *TwF* constitutes an extended vibrating field with a central point at rest in its proper reference frame. In such a reference frame it has a proper period T_0, frequency ν_0 and energy $E_0 = h\nu_0$ concentrated around the central point. Having energy the *TwF* has also mass m_0 concentrated around the central point as well. The central point of the *TwF* constitutes its center of mass (*CM*). The *TwF* has also an incessantly vibrating center of energy (matter) density (*CED*). The *CED* vibrates in the circumambiency of the *CM*. The *CED* as distinct from the *CM* has been introduced (by means of a hydrodynamic model) into the relativistic wave mechanics by Bohm and Vigier.[42]

The frequency of the *CED* vibration is equal to that of the *TwF* and is in phase with it where the *CED* vibrates. The *CED* vibration as a *CED* vibration of a wave field is wave-like i.e. its frequency transforms according to the eq. $\nu = \nu_0 (1-v^2/c^2)^{-1/2}$ as opposed to the frequency of a clock-like vibration which transforms according to the eq. $\nu = \nu_0 (1-v^2/c^2)^{-1/2}$. There is no reference frame of the central point of the *TwF* in which the *CED* does not vibrate. Also in this sense Einstein's relativistic ether is never quiet. The *CED* as an active oscylating point "produces" in Einstein's relativistic ether two wave fields. One propagating at superluminal velocities (from ∞ to c) and another propagating at subluminal velocities (from 0 to c).

(1) The superluminal wave field constitutes the first component of the *TwF*. The *CM* and the *CED* are surrounded first of all by de Broglie wave field (*BwF*) the waves (*B*-waves) of which are described by the well known function :

$$\psi_B(x, y, z, t) = a \exp[2\pi i\nu(t-x/u)]$$

(with well determined amplitude a) and characterized by the physical quantities : phase velocity $u = c^2/\mathrm{v} > c$ and wavelength $\lambda_B = h/m\mathrm{v} = (h/E)\,u$ (where c is the velocity of light and v the velocity of *CM*).

According to the *TwH*, the *Bwf* constitutes a particular kind of superluminal radiation which does not transport energy but transports a special kind of momentum $\vec{p}_B = (h/c^2)\,{}_B\vec{u}$ (momentum of Einstein's relativistic ether wave excitation).[39]

The *BwF* penetrates the whole empty space (i.e. the unoccupied Eintein's relativistic ether). In the proper reference frame of the *TwF*, the *BwF* is characterized by an infinite wavelength of its waves and propagates at infinite phase velocity in all directions beginning from the central point. If in a locally inertial reference frame (which constitutes our laboratory frame) the *CM* moves at constant velocity v, e.g. in the $+x$ direction along the x axe, then the *BwF* appears as propagating from the central point at different superluminal velocities in different directions : from the infinite velocity in the direction parallel to the y, z plane to the least one $u_{+x} = c^2/\mathrm{v}_{+x} > \mathrm{c}$ in the $+x$ direction (where v_{+x} is the velocity of (*CM*). The wavelengths of the *B*-waves (of the *BwF* propagating in this way), diminish from the infinite wavelength in the directions parallel to the y, z plane to the shortest one $\lambda_{B+x} = h/m\mathrm{v}_{+x} = (h/E)\,u_{+x}$ in the $+x$ direction.

In all directions which are not parallel to the y, z plane and not parallel to the $+x$ axe the *BwF* propagates at velocities smaller than infinite but greater than u_{+x} and its *B*-waves have wavelengths shorter than infinite but longer than λ_{B+x}.

If we place a set of observers (stationary with respect to the laboratory frame) on a plane parallel to the y, z plane in a certain distance from the y, z plane in the $+x$ direction, then the *CM* (moving along the x axe) moves only in the direction of one observer A_0 which is placed where the mentioned plane intersects with the x axe. The *CM* can move only in a unique direction but it approaches other observers of the plane as well at varying velocity smaller then v_{+x}. The shortest distance of approach is equal A_0A_n when the *CM* meets A_0. At that moment the velocity of approach is equal to zero. The *CM* does not meet other observers but the *BwF* arrives at all of them and it is important to note that it happens at the same time. This relativistic effect can be presented by means of geometrical diagrams. We will note here only that this effect is a simple consequence of de Broglie relation $c^2 = vu$. The slower the *CM* approaches an observer the faster the *BwF* propagates in his direction and therefore the propagating *BwF* meets all the observers even the most distant ones at the same time. The *B*-waves surfaces of the *BwF* appear to them as planes which approach at velocity u equal to the phase velocity u_{+x} of the *B*-wave which meets the observer A_0.

(2) The *BwF*, if observed from different reference frames has different relativistic images in every of them. These images if observed from the laboratory frame constitute a particular superimposition of *B*-waves. L. Mackinnon who is the first who indicated this relativistic effect has also shown that it constitutes a nondispersive wave-packet having properties of a soliton.[43-45] Mackinnon's soliton is characterized by a Compton transforming wavelength $\lambda_C =$

$= \lambda_{\circ C}(1-v^2/c^2)^{1/2}$ and an intrinsic phase velocity c. It is described in our laboratory frame by the function :

$$\psi_C(r, x, t) = [\sin(kr)/kr] \exp[i(\omega t - k_0 x)$$
with $k = m_0 c/h$, $r = [(x-vt)^2/(1-v^2/c^2)+y^2+z^2]^{1/2}\omega = mc^2/h, k_0 = mv/h$

The solitary *C*-wave constitutes the second component of the *TwF*. Its formation can be presented by means of space-time diagrams.[43] Mackinnon's soliton constitutes an extended material microobject in the proper sense. The energy and the inertia of the *TwF* are closely connected with it. The nondispersive wavepacket forms itself where the *B*-waves are in phase and where herefore the amplitude of the packet is the greatest. The energy of the *TwF* is therefore concentrated in the solitary *C*-wave. Hence the *CED* is located inside the Mackinnon soliton and the inertia of the *TwF* is related to the amplitude terms of the solitary *C*-wave.[44]

(3) The mentioned above subluminal wave field (introduced in 1978 by the author[37]) the waves of which are described by the function :[38, 39]

$$\psi_D(x, y, z, t) = a \exp[-2\pi i \nu(t - x/v)$$

constitutes the third component of the threefold wave field (*TwF*). Its properties are in a certain sense opposite to those of the *BwF* and therefore it can be named as dual to the de Broglie wave field (*DwF*). Its waves (*D*-waves)* are characterized by the phase velocity $v < c$, wavelength $\lambda_D = h/mu = (h/E)v$ and momentum $\vec{p} = (h/c)v_D \vec{v}$.

The *DwF*, if observed from the proper reference frame of the *TwF* does not propagate at all. Its velocity and wavelength of propagation are equal to zero in all directions beginning from the central point. In the proper reference frame the *DwF* manifests itself only through the *CED* vibration as a merely local periodic phenomenon of frequency. If observed from our laboratory frame, the *DwF* propagates in different directions at different subluminal velocities : from the velocity equal to zero in the directions parallel to the y, z plane to the greatest one on the $+x$ direction equal to the *CM* velocity. The wavelengths of *DwF* propagation increase from zero in the directions parallel to the y, z plane to the longest one in the $+x$ direction

$$\lambda_{D+x} = h/mu_{+x} = (h/E)v_{+x}$$

In all directions which are not parallel to the y, z plane and to the $+x$ axe the

* In my unpublished paper written in 1978[37] the *D*-waves are named by me *V*-waves because of their subluminal velocity v. The name *D*-wave (dual to the de Broglie wave) has been introduced by R. Horodecki who on the basis of my unpublished paper (presented to him for an estimation) has formulated his own version of the *TWH*. In his works (Phys. Lett : 87 A:95 (1981) ; Phys. Lett. 91 A : 269 (1982) ; Phys. Lett. 96 A : 175 (1983) ; Lett. Nuovo Cimento 36:509 (1983) R. Horodecki propagates, develops and modifies my *TWH*. He thanks me for the basis provided for his works in Phys. Lett. 87 A : 95 (1981), see p. 97.

DwF propagates at velocities greater than zero but smaller than v_{+x} and has wavelengths longer than zero and shorter than λ_{D+x}.

The *DwF* propagates like expanding sphere the diameter of which increases in the direction $+x$. If we single out three points *AOB* of this diameter, then *A* does not move, *O* moves at velocity $(1/2)v_{+x}$ and *B* at velocity v_{+x} equal to the *CM* velocity. The *DwF* fellows the *CM* and propels it. The *DwF* front does not arrive at all our laboratory frame observers at the same time. (It reaches together with the *CM* the A_0 observer the first). This relativistic effect is a simple consequence of the *TWH* relation[37, 38].

$$\lambda^2_C = \lambda_B \lambda_D$$

based on the mentioned de Broglie relation. The *TWH* relation can be presented as follows

$$c^2 T^2_C = (uT_B)(vT_D)$$

(where $T_C = T_B = T_D$ (equal also to $T_{CED} = T_0(1-v^2/c^2)^{1/2}$,because conditions of local metrical homogeneity govern in our laboratory frame). The faster the *BwF* approaches an observer the slower the *DwF* propagates in his direction.

In our laboratory frame, the trajectory of the *CM* will be a straightline. The trajectory of the vibrating *CED* will have in a certain sense a wave-like form. The wavelength of such a wave-like trajectory is equal to the wavelength of the *D*-wave propagating in the $+x$ direction

$$\lambda_{CED_{\text{traj}}} = \lambda_{D+x} = v_{+x} T_D$$

Thus the $D\text{-wave}_{+x}$ manifests itself, in a certain sense, through the *CED* vibration.

In our laboratory frame, the *DwF* carries the *C*-wave soliton on its wavefront at the point which propagates the fastest i.e. where we find the wavefront of the longest *D*-wave λ_{D+x} and in the direction indicated by the wave vector :

$$k_{D+x} = 2\pi/\lambda_{D+x}$$

CONCLUSION

The conclusion of this paper is the following. An elementary particle can be presented as a threefold wave field (*TwF*) on top of Einstein's relativistic ether (*ERE*). In such a *TwF* the *C*-wave soliton constitutes an extended microobject in the proper sense. Such a microobject stores up the whole energy of the *TwF* in its intrinsic *C*-wave vibration, has inertia properties and is characterized by a transforming Compton wavelength. The Compton wavelength of the intrinsic *C*-wave vibration belongs to the internal structure of the microobject.

An elementary particle however, is not only a microobject but also an extended widespread wave field composed of the *BwF* and the *DwF*. The superluminal *BwF* precedes the soliton-microobject preparing the way for it among different obstacles [37–39] Other solitons-microobjects are obstacles for the *BwF* and the *DwF*. The *BwF* is responsible for all reflexion, dyfraction,

interference and superluminal correlation phenomena.[37-39] The *DwF* follows the soliton-microobject and propels it in the space-time where the *BwF* has prepared the way. It is responsible for all energy exchange phenomena because carrying the soliton-microobject it carries also its energy and inertia.[38,39]

All the three wave fields are relativistic wave fields on top of Einstein's relativistic ether. Their physical quantities are intimately interconnected and correlated[37-39]. Their interconnection and correlation find an expression e.g. in the following equations :

$$\lambda^2{}_C = \lambda_B \lambda_D, \; k^2{}_C = \vec{k}_B \vec{k}_D \quad p^2{}_C = \vec{p}_B \vec{p}_D$$

(where k_C is the wave number and p_C the intrinsic momentum of the solitary C-wave; $\vec{k}_B$ and $\vec{k}_D$, $\vec{p}_B$ and $\vec{p}_D$ the respective wave vectors and momenta of the B-waves and of the D-waves).

Summarizing we can say. The physical space (closely connected with time) conceived nonatomically and nonmechanically (i.e. *ERE*) constitutes a material active subquantal medium the activity of which manifests itself, among other things, through the creation of the elementary particles. We are able to describe this creation if we use de Broglie introduction of Planck's constant into relativity theory.

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