V. Krasnoholovets, Inerton fields: Very new ideas on fundamental physics, American Inst. Phys. Conf. Proc. - December 22, 2010 - Volume **1316**, pp. 244-268. SEARCH FOR FUNDAMENTAL THEORY: The VII International Symposium Honoring French Mathematical Physicist Jean-Pierre Vigier (12-14 July 2010, Imperial College, London), Eds.: R. L. Amoroso, P. Rowlands and S. Jeffers; doi:10.1063/1.3536437 (Issue Date: 22 December 2010).

INERTON FIELDS: VERY NEW IDEAS ON FUNDAMENTAL PHYSICS

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Abstract. Modern theories of everything, or theories of the grand unification of all physical interactions, try to describe the whole world starting from the first principles of quantum theory. However, the first principles operate with undetermined notions, such as the wave ψ-function, particle, lepton and quark, de Broglie and Compton wavelengths, mass, electric charge, spin, electromagnetic field, photon, gravitation, physical vacuum, space, etc. From a logical point of view this means that such modern approach to the theory of everything is condemned to failure… Thus, what should we suggest to improve the situation? It seems quite reasonable to develop initially a theory of something, which will be able to clarify the major fundamental notions (listed above) that physics operates with every day. What would be a starting point in such approach? Of course a theory of space as such, because particles and all physical fields emerge just from space. After that, when a particle and fields (and hence the fields' carriers) are well defined and introduced in the well defined physical space, different kinds of interactions can be proposed and investigated. Moreover, we must also allow for a possible interaction of a created particle with the space that generated the appearance of the particle. The mathematical studies of Michel Bounias and the author have shown what the real physical space is, how the space is constituted, how it is arranged and what its elements are. Having constructed the real physical space we can then derive whatever we wish, in particular, such basic notions as mass, particle and charge. How are mechanics of such objects (a massive particle, a charged massive particle) organised? The appropriate theory of motion has been called a sub microscopic mechanics of particles, which is developed in the real physical space, not an abstract phase space, as conventional quantum mechanics does. A series of questions arise: can these two mechanics (submicroscopic and conventional quantum mechanics) be unified?, what can such unification bring new for us?, can such submicroscopic mechanics be a starting point for the derivation of the phenomenon of gravity?, can this new theory be a unified physical theory?, does the theory allow experimental verification? These major points have been clarified in detail. And, perhaps, the most intriguing aspect of the theory is the derivation of a new physical field associated with the notion of mass (or rather inertia of a particle, which has been called the inerton field and which represents a real sense of the particle's wave ψ-function). This field emerges by analogy with the electromagnetic field associated with the notion of the electric charge. Yes, the postulated inerton field has being tested in a series of different experiments! Even more, the inerton field might have a number of practical applications…

INTRODUCTION

Typically the study of the fundamentals and the problems in the area of fundamental physics starts from the reading of works of classical physicists and mathematicians of the past. As a rule, researchers begin from new ideas of Einstein of 1905. Indeed, Einstein introduced an interesting abstract approach to physics, which nearer to the mid-20th century was called the physical mathematics. The majority of physicists pointed out that Einstein showed a new interpretation of physical laws, which do not require a detailed knowledge about the ether at all. And hence that mysterious substrate was initially rejected from a physical pattern of the world at all, but later on it was substituted with a vague physical vacuum that started to play an important role in quantum and particle physics simply as a level of reference for the appearance of particles.

Modern physicists basing on an abstract formalism wish to develop a theory of everything, or a theory of the grand unification of all physical interactions. By doing this, they put in the background of the theory a number of very principal, but at the same time complete undetermined notions, such as the wave ψ-function, particle, lepton and quark, de Broglie and Compton wavelengths, mass, electric charge, spin, electromagnetic field, photon, gravitation, physical vacuum, space, etc.

Can we improve the situation and suggest something that will be able to shed light on the listed fundamental notions? It seems quite reasonable to develop initially a theory of something, which will be able to clarify the major fundamental notions that physics operates with every day. But what would be a starting point in such approach?

I was trained as a condensed matter physicist and defended a Ph.D. thesis just in this area. That is why my first views on the fundamentals in many aspects were very different from those of colleagues who were trained from the beginning as specialists in quantum theory and /or general relativity. In solid-state physics when one studies the motion of particles, it is important to take into account a possible influence on this motion on the side of the crystal lattice. The crystal lattice introduces a perturbation to the motion of the particle, which takes place first of all via the phonon subsystem (for example, polarons, polaritons, the Cooper electron pairs in superconductors, etc.). Thus I started to search for a background substrate, which could play the same role in quantum physics, as the crystal lattice plays in solid-state physics. Such searches stimulated me to scrutinize works of high-level physicists preceded Einstein.

So, what was before 1905? Lorentz and Poincaré believed that fundamental physics should be deterministic; moreover, an important element of the theoretical physics was a detailed description of a physical process, not only the prediction of a phenomenon. In contrast, in modern theoretical physics a detailed description becomes practically impossible due to a probabilistic concept used by physicists, which is based on uncertain rules for physical laws, and the complete indeterminism. It seems the difference in two kinds of the approaches is hidden in the perception of a primary physical matter (an ether) in which all events were developing by previous physicists, and the imperception of such a primary substrate by modern physicists.

Many scientists have read the fundamental work of Poincaré [1], but rather nobody paid attention to a pattern of the moving electron, as it was understood by leading physicists at the border of 19^{th} and 20^{th} centuries. In the meantime, the electron was treated as a singularity in the ether, which was moving surrounded by the ether excitations. The next interesting remark of Poincaré, which also so far did not attract an attention of physicists, dealt with the nature of gravitation. He noted that the expression for the attraction should include two components: one should be parallel to the vector that joins positions of both interacting objects and the second one be parallel to the velocity of the attracted object; in other words: the velocity of an object must influence the value of its gravitational potential.

In 1919^{th} the verified predictions of Einstein's general relativity stopped further development of ideas mentioned in the paper of Poincaré [1] and physics became to advance in the framework of formal abstract approaches. In 1924 de Broglie [2] studying analytical mechanics of a material point compared the principles of least actions of Maupertuis for a particle and the Fermat's for a phase wave, which gave him a possibility to conclude that a point particle is guided by a real phase wave. De Broglie suggested two major relationships for a particle that is accompanied with such wave:

$$E = h\nu, \quad p/h = \lambda. \tag{1}$$

In 1952 David Bohm [3] further developed the initial ideas of de Broglie with the concept of a pilot wave, though his wave still remained abstract. Bohm's works [3] tuned de Broglie back to his previous ideas, which he formulated as the search for a double solution theory [4]; he rejected the notion of wave-particle and treated a solution for a particle moving together with a real wave excited in a sub quantum medium, which guided the particle. Further studies of de Broglie ideas by his followers J.-P. Vigier, J. Andrade e Silva and G. Lochak were directed to an understanding of properties of this wave and the sub quantum medium in which the wave and the particle should travel.

Although de Broglie's thesis [2] was imbued with ideas of relativity, his attempt to unify a point particle with a wave that accompanies it, as well as searching for a double solution theory allow us to conclude that his views reflected a major concept of Poincaré: a moving particle is surrounded by excitations whose source is the ether. Thus, we may assume that de Broglie's theory of the real wave, which accompanies a moving particle, simply put in order the ether excitations that surround a moving particle, as was prescribed by Poincaré.

My studies on the fundamentals started in the end of 1980s and the main challenge was to connect de Broglie's real wave, which accompanies a moving particle, with Poincaré's excitations of the ether (or a sub quantum medium), which surround a travelling particle. It was interesting to put in order those excitations around a material particle in such a way that they could form a de Broglie's wave. Such connection would provide an opportunity to investigate both the structure and properties of this sub quantum medium and the principles of motion of objects in it. After that having known a detailed structure of a primary physical substratum, we could try to develop some other fundamental notions, such as the spin, electric charge, gravitation and so on.

THE STRUCTURE OF PHYSICAL SPACE

In physics *space* is defined via measurement and the standard space interval, called a standard meter or simply meter, is defined as the distance traveled by light in a vacuum per a specific period of time and in this determination the velocity of light *c* is treated as constant. In classical physics, *space* is a three-dimensional Euclidean space where any position can be described using three coordinates. In relativistic physics researchers operate with the notion of space-time in which matter is able to influence space. In microscopic physics, or quantum physics, the notion of *space* is associated with an "arena of actions" in which all physical processes and phenomena occur. And this arena of actions we feel subjectively as a "receptacle for subjects".

However, let us critically look at the determination of *physical space* as an "arena of actions". In such a determination there exists, first, subjectivity and, second, objects themselves that play in processes can not be examined at all (for instance, size, shape and the inner dynamics of the electron; what is a photon?; what are the particle's de Broglie wavelength λ and Compton wavelength $\lambda_{\rm Com}$?; how to understand the notion/phenomenon "wave-particle"?; what is spin?; what is the mechanism that forms Newton's gravitational potential $-Gm/r$ around an object with mass *m*?; what does the notion 'mass' mean exactly?, etc. Especially interesting are some examples of the motion "on the arena of action, as a reservoir for objects". For instance, when a vehicle suddenly jams on the brakes, an experienced physicist sitting in the vehicle will feel that something pushes him forward. This example clearly gives evidence of the existence of otherworldly forces at the scene of action among normal subjects.

However, this "arena of actions" can be completely formalized, such that those mystical forces (veiled under the force of inertia and the centrifugal force) will unravel explicitly, because fundamental physical notions and interactions are to be derived from pure mathematical constructions.

So far in mathematics, a space has been treated as a set with some particular properties and usually some additional structure. It is not a formally defined concept as such but a generic name for a number of similar concepts, most of which generalize some abstract properties of the physical concept of space. Distance measurement is abstracted as the concept of metric space and volume measurement leads to the concept of measured space.

Generalization of the concept of space can be done [5-8] through set theory, topology and fractal geometry, which will allow us to look at the problem of the constitution of physical space from the most fundamental standpoint. The fundamental metrics of our ordinary space-time is a convolution product in which the embedded part looks as follows:

$$U4 = \int\left(\int_{dS}\left(d\vec{x}\cdot d\vec{y}\cdot d\vec{z}\right)\right) * d(w) \tag{2}$$

where dS is the element of space-time, $d\Psi(x)$ is the function that accounts for the expansion of 3-D coordinates to 4-th dimension through the convolution with the volume of space. Set theory, topology and fractal geometry allow us to consider the problem of structure of space as follows. According to set theory only an empty set $\varnothing$ can represent nothing. Following von Neumann, Bounias and the author considered an ordered set,

$$\{\{\varnothing,\{\varnothing\}\}\},\{\{\varnothing,\{\varnothing,\{\varnothing\}\}\}\},\{\{\varnothing,\{\varnothing,\{\varnothing,\{\varnothing\}\}\}\}\},\{\{\varnothing,\{\varnothing,\{\varnothing,\{\varnothing,\{\varnothing\}\}\}\}\}\} \text{ and so on.}$$

By examining the set, one can count its members: $\{\varnothing\} = 0$, $\{\varnothing,\{\varnothing\}\} = 1$, $\{\varnothing,\{\varnothing,\{\varnothing\}\}\} = 2$, … This is the empty set as long as it consists of empty members and parts. On the other hand, it has the same number of members as the set of natural integers, $N = 0,\ 1,\ 2,\ 3,\ ...,\ n$. Although it is proper that reality is not reduced to enumeration, empty sets give rise to mathematical space, which in turn brings about physical space. So, something can emerge from emptiness. The empty set is contained in itself, hence it is a non-well-founded set, or hyperset, or empty hyperset. Any parts of the empty hyperset are identical, either a large part $(\varnothing)$ or the singleton $\{\varnothing\}$; the union of empty sets is also the same: $\varnothing \cup (\varnothing) \cup \{\varnothing,\{\varnothing\}\} \cup \{\varnothing,\{\varnothing,\{\varnothing\}\}\} \cup ... = \varnothing$. This is the major characteristic of a fractal structure, which means the self-similarity at all scales (from the elementary subatomic level to cosmic sizes).

One empty set $\varnothing$ can be subdivided into two others; two empty sets generate something $(\varnothing)\cup(\varnothing)$ that is larger than the initial element. Consequently, the coefficient of similarity is $\rho \in [1/2,\ 1]$. In other words, ρ realises fragmentation when it falls within the interval $]1/2,\ 1[$ and the union of ρ with interval $]0,\ 1/2]$ gives $]0,\ 1\,[$. The coefficient of similarity ρ allows us to estimate the fractal dimension of the empty hyperset; since this dimension contains the interval $]0,\ 1[$ as one of its components, it turns out that it is a "fuzzy" dimension. 4D mathematical spaces have parts in common with 3D spaces, which yields 3D closed structures. There are then parts in common with 2D, 1D and zero dimension (points). General topology indicates the origin of time, which should be treated as an assembly of sections of open sets (Poincaré sections).

Primary topology is a topology of open sets (in particular, the empty set $\varnothing$ is an open set, but its topological ball is not open). That is why primary topology cannot be a physically measured space. However, the availability of closed intersections (timeless Poincaré sections) of abstract mathematical spaces creates properties typical for a physical space.

Any space can be subdivided in two major classes: objects and distances. In spaces of the type $\Re^n$, tessellation by balls is involved, which again requires a distance to be available for measurement of diameters of intervals. Intervals can be replaced by topological balls and therefore evaluation of their diameter still needs an appropriate general definition of a distance.

Providing the empty set $(\varnothing)$ with mathematical operations $\in$ and $\subset$, as combination rules, and also the ability of complementary $(\mathbf{C})$ we obtain a magma (i.e. fusion) of empty sets: Magma is a union of elements $(\varnothing)$, which act as the initiator polygon, and complementary $(\mathbf{C})$, which acts as the rule of construction; i.e., the magma is the generator of the final structure. This allowed Bounias [5,6] to formulate the following theorem:

The magma $\varnothing^{\varnothing} = \{\varnothing, \mathbf{C}\}$ constructed with the empty hyperset and the axiom of availability is a fractal lattice.

Writing $(\varnothing^{\varnothing})$ denotes the magma, and reflects the set of all self mappings of $\varnothing$. The space, constructed with the empty set cells of the magma $\varnothing^{\varnothing}$, is a Boolean lattice, and this lattice $S(\varnothing)$ is provided with a topology of discrete space. A lattice of tessellation balls has been called a tessel-lattice [6], and hence the magma of empty hyperset becomes a fractal tessel-lattice.

Our space-time then becomes one of the mathematically optimal morphisms and time is an emergent parameter indexed on non-linear topological structures guaranteed by discrete sets. This means that the foundation of the concept of time is the existence of orderly relations in the sets of functions available in intersect sections. Time is thus not a primary parameter and the physical universe has no beginning: time is just related to ordered existence, not to existence itself. The topological space does not require any fundamental difference between reversible and steady-state phenomena, nor between reversible and irreversible process. Rather relations simply apply to non-linearly distributed topologies and from rough to finest topologies.

So real physical space can be presented in the form of a mathematical lattice: the tessel-lattice is regularly ordered such that the packing has no gaps between two or more empty topological balls. Such tessel-lattice accounts for the existence of relativistic space and the quantum void (vacuum), as: 1) the conception of distance and the conception of time are defined and 2) such space includes a quantum void, because the mosaic space introduces a discrete topology with quantum scales and, moreover, it does not have "solid objects" that would appear as real matter. The tessel-lattice with these characters has properties of a degenerate physical space. The sequence of mappings from one structural state to the other of an elementary cell of the tessel-lattice generates an oscillation of the cell's volume along the arrow of physical time. However, there is also an option of transformation of a cell under the influence of some iteration similarity that overcomes conservation of homeomorphism (Figures 1 and 2).

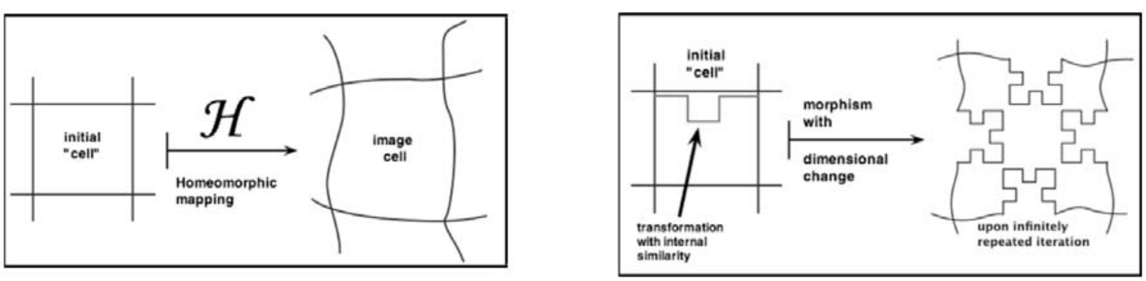

FIGURE 1. The continuity of homeomorphic mappings of structures is broken once a deformation involves an iterated transformation with internal self-similarity, which involves a change in the dimension of the mapped structure. Here the first 2 or 3 steps of the iteration are sketched, with basically the new figure jumping from (D) to approximately (D + 1.45). The mediator of transformations is provided in all cases by empty set units.

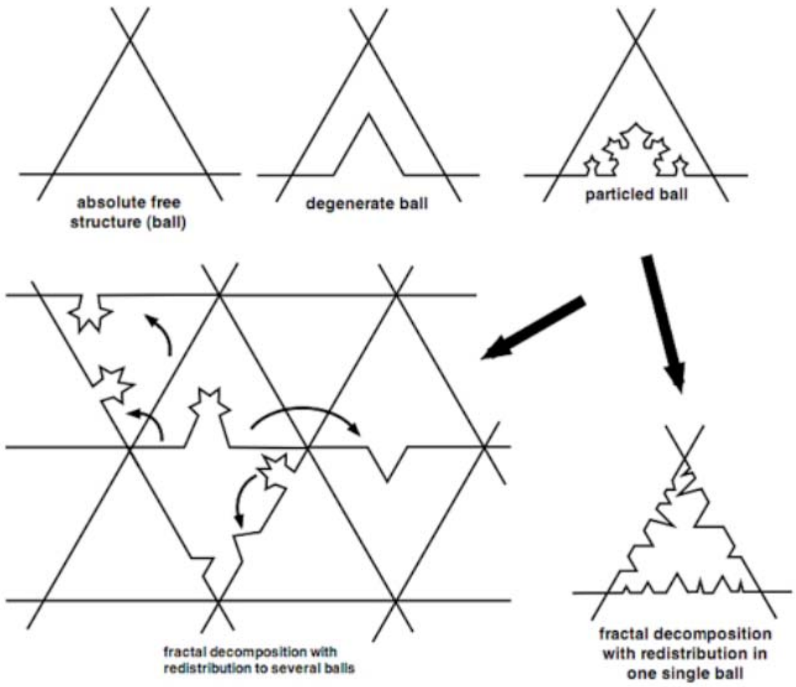

FIGURE 2. A topological ball is represented as a triangle, figuring 3 dimensions in a metaphorical form. A degenerate ball keeps the same dimension in contrast with a particled ball endowed with a fractal substructure. A complete decomposition into one single ball (k = 1) conserves the volume without keeping the fractal dimension. The von Koch-like fractal has been simplified to 3 iterations for clarity.

The universe can be treated as a tessel-lattice composed of a huge number of cells, or topological balls. The measure includes such notions as length, surface and volume. Because of that a loop distance ℓ of the universe (i.e. the perimeter that would be measured by means of a ruler in principle) can be related to parameters of N balls.

Indeed, let μ be a measure of balls (their length, surface or volume with the corresponding dimensions $\delta =$ 1-D, 2-D or 3-D). In the middle part of the universe with the dimension D we have N times μ^{δ}, which equals approximately ℓ^{D}, so that we estimate the dimention of this part of the universe:

$$D \sim (\delta \cdot \log \mu + \log N) / \log \ell \tag{3}$$

Thus, from expression (3) we can see that at least a part of the universe having different dimension D can be distinguished from the other universe, which can be perceived as the presence of dark matter there.

If we know the universe's components, i.e. if we can describe sizes and shapes of topological balls (from the Planck size), we will be able to re-establish an invisible structure of a large size (up to a cosmic size).

The organisation of matter at the microscopic (atomic) level has to recreate a sub microscopic spatial ordering. Hence the crystal lattice is also a reflection of the sub microscopic ordering of real physical space that can be associated with the tessel-lattice of tightly packed balls – elementary bricks of the primary substrate of the universe. The size of a cell in the tessel-lattice can be equal to the Planck's length $l_{\text{Planck}} = \sqrt{\hbar G / c^3} \approx 1.6 \times 10^{-35}$ m.

SUBMICROSCOPIC MECHANICS

In mechanics the behavior of a particle can be described on the basis of an appropriate Lagrangian. In the simplest case when a potential energy is absent, a particle is characterized by its kinetic energy $m\upsilon^2 / 2$.

Now let us consider mechanics of a local deformation (Figure 1, right) in the tessel-lattice, i.e. in the case of tight contact of the deformation with surrounding cells. In the tessel-lattice balls are found in a degenerate state and their characteristics are such mathematical parameters as length, surface, volume and fractality. Evidently, the removal of degeneracy must result in local phase transitions in the tessel-lattice, which creates "solid" physical matter (Figure 1, right; Figure 2). A local fractal volumetric deformation of a ball in the tessel-lattice can be associated with the physical notion of mass. The theorem of something occupies the first place, i.e. a peculiar object becomes primary, which is typical for set theory. Then, having a definition of the primary 'something', we can study its behavior in the tessel-lattice, i.e. space mosaically composed of primary bricks, or topological balls. Thus a mass of a particle has to be considered as a ratio of the initial volume V_0 of the degenerate ball in the tessel-lattice to a volume V_{def} of a ball that has undergone a fractal volumetric deformation, i.e.

$$m = \text{const}\ V_0 / V_{\text{def}}\ . \tag{4}$$

The behavior of a particle has to obey a special kind of a mechanics, which includes the interaction of the moving particle with the surrounding tessel-lattice. It is quite obvious that a moving particle excites the tessel-lattice, which brings about the appearance of excitations. These excitations should go out of the particle and then come back to it. Note these excitations must return to the particle, because in the other case the friction of the particle against the tessel-lattice's cells will stop the particle forever.

The Lagrangian that is able to satisfy the described motion of a particle and the ensemble of excitations can be written as in (see more accurate presentation in Refs. [10-12])

$$L = \tfrac{1}{2} g_{ij} \frac{dX^i}{dt}\frac{dX^j}{dt} + \tfrac{1}{2}\sum_{i,j;\alpha} \tilde{g}_{ij}^{(\alpha)} \frac{dx^{(\alpha)i}}{d\tilde{t}_{(\alpha)}}\frac{dx^{(\alpha)j}}{d\tilde{t}_{(\alpha)}} - \sum_{i,j}\frac{\pi}{T_{(\alpha)}}\left[X^i \sqrt{g_{is}\tilde{g}_{si}^{(\alpha)}}\,\frac{dx^{(\alpha)j}}{d\tilde{t}_{(\alpha)}} + \upsilon_0^i \sqrt{g_{is}\tilde{g}_{sj}^{(\alpha)}}\,x^{(\alpha)j}\right] \tag{5}$$

where the first term characterizes the kinetics energy of the particle, the second term characterizes the kinetics energy of the ensemble of *N* excitations emitted from the particle and the third term specifies the contact interaction between the particle and the excitations: some excitations are emitted and the other are absorbed. X^i is the *i*th component of the position of the particle; g_{ij} is metric tensor components generated by the particle; υ_0^i is the *i*th component of the initial particle's velocity vector $\mathbf{v}_0$. Index α corresponds to the number of respective excitations; $x^{(\alpha)i}$ is the *i*th component of the position of the αth excitation; $\tilde{g}_{ij}^{(\alpha)}$ is the metric tensor components of the position of the αth inerton. $1/T_{(\alpha)}$ is the frequency of collisions of the particle with the αth excitation. Proper times of the particle and the αth excitation are *t* and $\tilde{t}_{(\alpha)}$, respectively.

In the so-called relativistic case when the initial velocity υ_0 of the particle is close to the speed of light *c*, the relativistic mechanics prescribes the Lagrangian

$$L_{\text{rel}} = -m_0 c^2 \sqrt{1 - \upsilon_0^2 / c^2}\ . \tag{6}$$

On examination of the relativistic particle, we shall introduce into the Lagrangian (6) terms, which describe the moving particle and an ensemble of excitations that accompany it (see more accurate presentation in Refs. [11,12]):

$$L_{\text{rel.}} = -gc^2 \left\{ 1 - \frac{1}{gc^2}\left[g_{ij}\frac{dX^i}{dt}\frac{dX^j}{dt} + \sum_{i,j;\alpha}\tilde{g}_{ij}^{(\alpha)}\frac{dx^{(\alpha)i}}{d\tilde{t}_{(\alpha)}}\frac{dx^{(\alpha)j}}{d\tilde{t}_{(\alpha)}} - \sum_{i,j;\alpha}\frac{2\pi}{T_{(\alpha)}}\left(X^i \sqrt{g_{is}\tilde{g}_{sj}}\,\frac{dx^{(\alpha)j}}{d\tilde{t}_{(\alpha)}} + \upsilon_0^i\sqrt{g_{is}\tilde{g}_{sj}}\,x^{(\alpha)j}\right)\right]\right\}^{\frac{1}{2}} \tag{7}$$

where $g = g_{ij}\delta^{ij}$.

The Euler-Lagrange equations

$$d[\partial L / \partial(dQ_n / dt_n)] / dt_n - \partial L / \partial Q_n = 0 \tag{8}$$

written for the particle ($Q_n \equiv X^i$) and the αth excitation ($Q_n \equiv x^{(\alpha)i}$), where respectively $t_n \equiv t$ and $t_n \equiv \tilde{t}_{(\alpha)}$, coincide for the Lagrangians (5) and (7). This is true only [11,12] in the case when the time *t* entered into the

Lagrangians (5) and (7) is considered as the natural parameter, i.e. $t = \ell / \upsilon_0$ where ℓ is the length of the particle path (and the same for excitations, $\tilde{t} \equiv \tilde{t}_{(\alpha)} = \ell_{(\alpha)} / c$).

Omitting the index α at the corresponding excitation, we may present equations of extremals as follows

$$\frac{d^2 X^k}{dt^2} + \Gamma^k_{ij} \frac{dX^i}{dt} \frac{dX^j}{dt} + \frac{\pi}{T} g^{ki} \sqrt{g_{iq} \tilde{g}_{qj}} \frac{dx^j}{dt} = 0 , \tag{9}$$

$$\frac{d^2 x^k}{dt^2} + \tilde{\Gamma}^k_{ij} \frac{dx^i}{dt} \frac{dx^j}{dt} - \frac{\pi}{T} \tilde{g}^{ki} \sqrt{g_{iq} \tilde{g}_{qj}} \left(\frac{dX^j}{d\tilde{t}} - \upsilon_0^j \right) = 0 ; \tag{10}$$

here, Γ^k_{ij} and $\tilde{\Gamma}^k_{ij}$ are symmetrical connections (see, e.g. Ref. [12]) for the particle and for the αth excitation, respectively; indices *i*, *j, k* and *q* take values 1, 2, 3. When the particle and the αth excitation adhere, the termwise difference between eqs. (9) and (10) becomes [10-12]

$$\left(\frac{d^2 X^k}{dt^2} - \frac{d^2 x^k}{d\tilde{t}^2} \right) + \left(\Gamma^k_{ij} \frac{dX^i}{dt} \frac{dX^j}{dt} - \tilde{\Gamma}^k_{ij} \frac{dx^i}{d\tilde{t}} \frac{dx^j}{d\tilde{t}} \right) = 0 . \tag{11}$$

Eq. (11) specifies the merging the particle and the αth excitation into a common system. This means the accelerations, which the particle and the αth ecitation experience, coincide. Then the difference in the first set of parentheses in eq. (11) is equal to zero and we get

$$\Gamma^k_{ij} (dX^i / dt)(dX^j / dt) = \tilde{\Gamma}^k_{ij} (dx^i / d\tilde{t}) (dx^j / d\tilde{t}) \tag{12}$$

Coefficients Γ^k_{ij} and $\tilde{\Gamma}^k_{ij}$ are generated by the particle mass *m* and the αth excitation mass $m_{(\alpha)}$, respectively, and that is why $\Gamma^k_{ij} / \tilde{\Gamma}^k_{ij} = m / m_{(\alpha)}$. This signifies that relationship (12) can be rewritten explicitly

$$m \upsilon^2_{0(\alpha)} = m_{(\alpha)} c^2 . \tag{13}$$

for diagonal metric components of the particle and the excitation velocities, ($\upsilon_{0(\alpha)}$ is the velocity of the particle after its scattering by the αth excitation with the initial velocity *c*). The relationship (13) allows us to solve the equations of extremals (9) and (10).

We can see that these excitations appear as the inertia of the particle. That is why we [10] called them ***inertons***.

If we consider the ensemble of inertons as the whole object, as an inerton cloud with the rest mass μ, which surrounds a moving particle with the rest mass m_0, then the Lagrangian may be presented as

$$L_{\text{rel}} = -m_0 c^2 \left\{ 1 - \frac{1}{m_0 c^2} \left[m_0 \left(\frac{dX}{dt} \right)^2 + \mu \left(\frac{dx}{dt} \right)^2 - \frac{2\pi}{T} \sqrt{m_0 \mu} \left(X \frac{dx}{dt} + \upsilon_0 x \right) \right] \right\}^{\frac{1}{2}} \tag{14}$$

Thus the particle moves along the *X*-axis with the velocity dX / dt (υ_0 is the initial velocity); *x* is the distance between the particle and the centre-mass of the inerton cloud, dx / dt is the velocity of the cloud, $1/T$ is the frequency of collisions between the particle and its inerton cloud, and *t* is the proper time of the particle. The equations of motion become

$$\frac{d^2 X}{dt^2} + \frac{\pi \upsilon_0}{cT} \frac{dx}{dt} = 0 , \tag{15}$$

$$\frac{d^2 x}{dt^2} - \frac{\pi c}{T \upsilon_0} \left(\frac{dX}{dt} - \upsilon_0 \right) = 0 . \tag{16}$$

The corresponding solutions to eqs. (15) and (16) for the particle and the inerton cloud are

$$\frac{dX}{dt} = \upsilon_0 \cdot \left(1 - \left| \sin(\pi t / T) \right| \right), \tag{17}$$

$$X(t) = \upsilon_0 t + \frac{\lambda}{\pi}\left\{(-1)^{[t/T]}\cos(\pi t/T) - (1 + 2\,[t/T])\right\}, \quad (18)$$

$$\lambda = \upsilon_0 T\,; \quad (19)$$

$$\frac{dx}{dt} = c\,(-1)^{[t/T]}\cos(\pi t/T)\,, \quad (20)$$

$$x(t) = \frac{\Lambda}{\pi}\left|\sin(\pi t/T)\right|, \quad (21)$$

$$\Lambda = cT\,. \quad (22)$$

Expressions (17)-(22) show that the velocity of the particle periodically oscillates and λ is the amplitude of particle's oscillations along its path. In particular, λ is the period of oscillation of the particle velocity that periodically changes between υ_0 and zero. The inerton cloud periodically leaves the particle and then comes back; Λ is the amplitude of oscillations of the cloud. Figures 3 show the solutions (17) and (18).

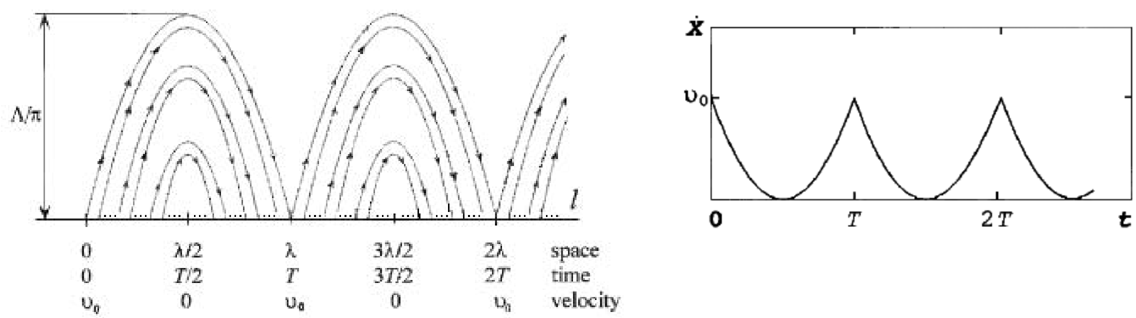

FIGURE 3. Behavior of the moving particle and its inerton cloud in space. In the section λ of the particle's pass the value of the particle's velocity oscillates between the initial magnitude υ_0 and zero. T is the time period of these oscillations. Periodically inertons fly away to the distance Λ from the particle and come back to it.

The frequency of collisions of the particle with the inerton cloud allows the presentation in two ways: via the collision of the particle with the cloud, i.e., $1/T = \upsilon_0/\lambda$ and via the collision of the inerton cloud with the particle, i.e., $1/T = c/\Lambda$. These two expressions result into relationship

$$\upsilon_0/\lambda = c/\Lambda\,, \quad (23)$$

which connects the spatial period λ of oscillations of the particle with the amplitude Λ of the inerton cloud, i.e., maximal distance to which inertons are travelling from the particle.

If we introduce a new variable

$$d\kappa/dt = dx/dt - (\pi/T)\sqrt{m_0/\mu}\;X \quad (24)$$

in the Lagrangian (14), we [11] can obtain an effective Hamiltonian of the particle that describes its behavior relative to the center of inertia of the particle-inerton cloud system

$$H_{\text{eff}} = \frac{p^2}{2m} + m\left(\frac{2\pi}{2T}\right)^2\frac{X^2}{2} \quad (25)$$

where $m = m_0/\sqrt{1-\upsilon_0^2/c^2}$. The harmonic oscillator Hamiltonian (25) allows one to write the Hamilton-Jacobi equation for a shortened action S_1 of the particle

$$\tfrac{1}{2}\left(\partial S_1/\partial X\right)^2/m + \tfrac{1}{2}m\left(2\pi/2T\right)^2 X^2 = E\,. \quad (26)$$

Here E is the energy of the moving particle. Introduction of the action-angle variables leads to the following increment of the particle action within the cyclic period $2T$,

$$\Delta S_1 = \oint p dX = E \cdot 2T \ . \tag{27}$$

One can write eq. (27) via the frequency $\nu = 1/2T$ as well. At the same time $1/T$ is the frequency of collisions of the particle with its inerton cloud. Owing to the relation $E = m\upsilon_0^2/2$ we also get

$$\Delta S_1 = m\upsilon_0 \cdot \upsilon_0 T = p\lambda \tag{28}$$

where $p = m\upsilon_0$ is the particle initial momentum. Now if we equate the value ΔS_1 and Planck's constant *h,* we obtain instead of expressions (27) and (28) de Broglie's relationships (1), which form the basis of conventional quantum mechanics, as they allow us to obtain the Schrödinger weave equation for a particle (see, e.g. de Broglie [13]).

In the submicroscopic mechanics presented, the oscillatory motion of the particle is characterized by the relation $\lambda = \upsilon_0 T$, which connects the initial velocity υ_0 of the particle with the spatial period λ of the particle oscillations (or the free path length of the particle), and the time interval T during which the particle remains free, i.e. does not collide with its inerton cloud. On the other hand, this relation holds for a monochromatic plane wave that spreads in the real physical space: λ is the wavelength, T is the period and υ_0 is the phase velocity of the wave. Thus with the availability of the harmonic potential, the behavior of the particle follows the behavior of a wave and, therefore, such a motion should be marked by a very specific value of the adiabatic invariant, or increment of the particle action ΔS_1 within the cyclic period. It is quite reasonable to assume that in this case the value of ΔS_1 is minimal, which is equal to Planck's constant h. Such minimal action means that the motion obeys the tessel-lattice's laws, i.e. undisturbed space guides the particle.

It is known from solid-state physics that a foreign particle deforms the crystal lattice of the substance studied (for instance, an electron or proton polaron in a polar medium). We have to anticipate that the same occurs in the tessel-lattice at the creation of a particle in it. That is, the created particle forms a deformation coat around the particle in the undisturbed tessel-lattice (Figure 4).

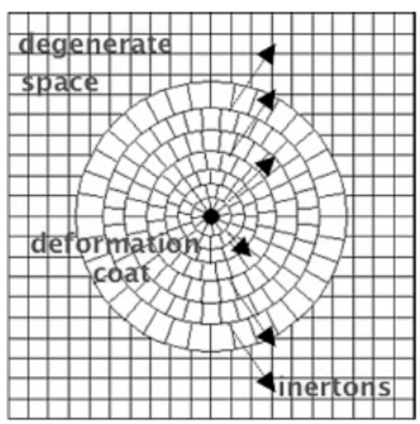

FIGURE 4. Particle forms the deformation coat in the tessel-lattice. The coat's state migrates by a hopping mechanism together with the moving particle. Cells from the deformation coat do not travel, but their tension state is transferred from cell to cell. The moving particle emits a cloud of inertons. The diameter of the deformation coat can be associated with the Compton wavelength $\lambda_{\rm Com}$ of the particle. The deformation coat plays a role of a screen that shields the particle from the degenerated space, i.e. undisturbed tessel-lattice.

The relationship (13) shows that the motion of a particle results in a decay of its mass, i.e. the particle's mass decomposes to the mass of emitted inertons. It is interesting to note that de Broglie [14], by using the variation principle applied for a relativistic particle, also showed that the motion should take place with a decay of the particle's mass. To understand this phenomenon, we have to look at the structure of the deformation coat that surrounds the particle. Figure 5 displays two different types of possible local volumetric deformations of the tessel-lattice.

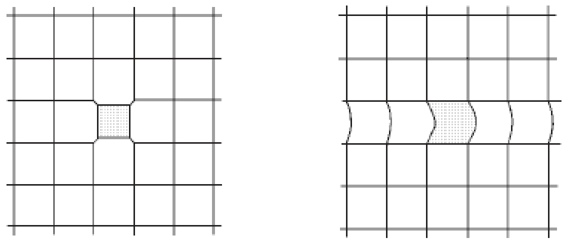

FIGURE 5. Two types of volumetric deformations of the tessel-lattice. The left one (the local deformation) corresponds to the physical notion of mass. The right one represents a new kind of physical property, a rugosity of the tessel-lattice (a kind of a tension of space).

The introduction of the deformation coat allows us to decide a few serious problems, which so far have been unsolved in quantum physics. First of them is the unification of the Schrödinger and Dirac formalisms. Let us consider three relationships for a particle: respectively the de Broglie and Compton wavelengths

$$\lambda = h/(m\upsilon) , \tag{29}$$

$$\lambda_{\text{Com}} = h/(mc) \tag{30}$$

and our expression (23), $\Lambda = \lambda c/\upsilon_0$, which characterizes the amplitude of inerton cloud. By combing these relationships we derive

$$\Lambda = \lambda_{\text{Com}} c^2/\upsilon_0^2 . \tag{31}$$

Correlation (31) shows that when the velocity of the particle υ_0 satisfies the inequality $\upsilon_0 << c$, the energy of inerton cloud is equal to the kinetic energy of the particle $E = \frac{1}{2}m\upsilon_0^2$ and the measuring device just fixes this energy by catching the cloud of inertons. In the case when $\upsilon_0 \to c$, the inerton cloud becomes practically closed in the range of the deformation coat (Figure 4). Hence in this case the measuring device will measure not only the kinetic energy of the particle, but its whole energy $E = m_0 c^2/\sqrt{1-\upsilon_0^2/c^2}$, which is concetrated in the deformation coat [16]. Thus two approaches to the description of a quantum system become complete clear: the Schrödinger formalism describes a particle whose inerton cloud spread far beyond the deformation coat and the Dirac formalism depicts a particle whose inerton cloud is practically closed in the framework of the deformation coat.

In submicroscopic mechanics the Dirac equation is derived [16] from the Hamiltonian that includes an intrinsic motion of the particle under consideration, i.e., a new term $c^2\vec{\pi}^2_{\uparrow(\downarrow)}$ that has not been taken into account so far and which characterizes proper pulsations of the particle between a bean-like and spherical shape in the section of λ (the particle's amplitude, or de Broglie wavelength)

$$H^{\text{particle total}}_{\uparrow(\downarrow)} = \sqrt{c^2\vec{p}^2 + c^2\vec{\pi}^2_{\uparrow(\downarrow)} + m_0^2 c^4} . \tag{32}$$

The Hamiltonian (32) includes additional terms associated with two possible projections of intrinsic pulsations of the particle: ahead and back. Therefore, if we decompose the square root in expression (32), which has a matrix form, we must obtain the equation in a matrix form too. This is the inner reason why the Dirac equation should possess matrix components associated with the particle spin. These inner pulsations make it possible to obtain the eigenvalues of the spin operator in the form of $S^z_{\uparrow(\downarrow)} = \pm\hbar/2$, which in the presents of a magnetic field B renormalizes the eigenvalue E of the particle to the quantity $E + eBS^z_{\uparrow(\downarrow)}/m$.

Particles that have an integral spin are particles combined of simple particles with half-integer spin.

The second problem, which resolved the sub microscopic concept, is associated with the nuclear forces. An approach resting on deriving of the nuclear forces from the quark-quark interaction still prevails in nuclear physics. Nevertheless, such an approach is open to question, especially owing to the confinement problem, which is the most difficult one for quantum chromodynamics (QCD). It is a matter of fact that the understanding how QCD works remains one of the great puzzles of many-body physics. Indeed, the degrees of freedom observed in low energy phenomenology are totally different from those appearing in the QCD Lagrangian. In the case of many-nucleon systems, the question of the origin of the nuclear energy scale is immediately arouse: the typical energy scale of QCD is on the order of 1 GeV, though the nuclear binding energy per particle is very small, on the order of 10 MeV. Is there some deeper insight from which this scale naturally arises? Or the reason should one searches in complicated details of near cancellations of strongly attractive and repulsive terms in the in the nuclear interaction? These issues were studied in paper [17].

In paper [17] the concept of the tessellated space and the sub microscopic mechanics were applied for in-depth study of the nucleon-nucleon interaction. It is argued that a deformation coat must be available around a nucleon (as is the case with any other canonical particle such as electron, muon, etc.) and that it is the deformation coat that is responsible for the appearance of nuclear forces (Figure 6). The radius of nuclear forces is associated with the radius of deformation coat of a nucleon, which in turn coincides with the nucleon's Compton wavelength $\lambda_{\rm Com}^{\rm (nucleon)} = h/(m_{\rm proton}c) \approx h/(m_{\rm neutron}c) \cong 1.32\times 10^{-15}$ m.

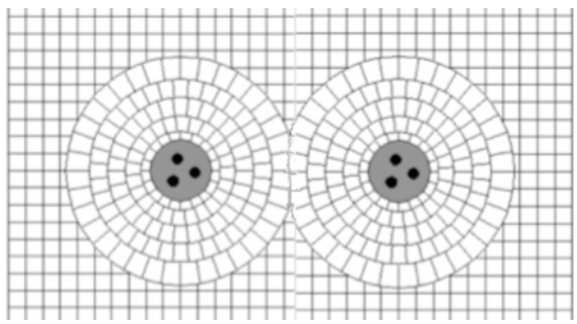

FIGURE 6. Two nucleons touch each other through their deformation coats. The radius of the deformation coat of each nucleon exactly corresponds to the nucleon's Compton wavelength.

Thus the consideration [17] shows that the coupling of nucleons through their deformation coats is a beneficial process. One more source of nuclear forces is associated with the overlapping of inerton clouds of moving nucleons, because basically excitations of the deformation coat have the same origin, as inertons of the nucleon's inerton cloud.

The third problem, which resolves the sub microscopic concept, is associated with the origin of gravitation and the quantum gravity.

GRAVITATION

Submicroscopic mechanics considered above looks like a kinetic theory of a particle that collides with its inerton cloud. However, a question arises: Why do inertons emitted by the moving particle come back to it?

The answer is hidden in the inner properties of the tessel-lattice. Namely, we must assume that the tessel-lattice posseses elastic properties and it is able to shrink due to a mechanical effect, but after that the tessel-lattice immediately restores its original state. So inertons irradiated by the particle experiences an elastic resistance to their migration on the side of the tessel-lattice: they gradually change their state, a local deformation μ disappears but a local tension ξ appears (Figure 5). At the maximum distance Λ from the particle the inertons' parameters are as follows: $\mu \to 0$, $\xi \to \xi_{\max}$ and the velocity $c_{\rm inerton} \to 0$. Then the locally shrank tessel-lattice restores its original state, namely, it returns inertons backward to the particle: in the course of the backward migration inertons loose ξ and gain μ. And this process represents the phenomenon of attraction, i.e. gravitation.

The cloud of inertons surrounding the particle spreads out to a range $\Lambda = \lambda c / \upsilon_0$ from the particle center where λ is the particle's de Broglie wavelength and υ_0 and c are velocities of the particle and light, respectively. Since inertons transfer fragments of the particle's mass, they also play the role of carriers of gravitational properties of the particle. First of all we should describe how inertons irradiated by the particle come back to it, returning fragments of its mass as well as the velocity. The behavior of the particle's inertons can be studied in the framework of the Lagrangian [18,19]

$$L = -m_0 c^2 \left\{ \frac{T^2}{2m_0^2} \dot{m}^2 + \frac{T^2}{2\Lambda^2} \dot{\vec{\xi}}^2 - \frac{T}{m_0} \dot{m} \nabla \vec{\xi} \right\}^{\frac{1}{2}} . \tag{33}$$

Here, $m(\vec{r}, t)$ is the current mass of the {particle-inerton cloud} system; $\vec{\xi}(\vec{r}, t)$ is the variable that describes a local distortion of the tessellattice, which can be called a tension (or rugosity); T is the time period of collisions of the particle and its inerton cloud. The Euler-Lagrange equations for variables m and $\vec{\xi}$ are

$$\frac{\partial^2 m}{\partial t^2} - \frac{m_0}{T} \nabla \dot{\vec{\xi}} = 0 , \tag{34}$$

$$\frac{\partial^2 \vec{\xi}}{\partial t^2} - \frac{\Lambda^2}{m_0 T} \nabla \dot{m} = 0 \tag{35}$$

Taking the initial and boundary conditions as well as the radial symmetry into account, we can obtain the following solutions to equations (34) and (35)

$$m(r, t) = C_1 \frac{m_0}{r} \cos \frac{\pi r}{2\Lambda} \left| \cos \frac{\pi t}{2T} \right| , \tag{36}$$

$$\xi(r, t) = C_2 \frac{\xi_{\max}}{r} \sin \frac{\pi r}{2\Lambda} \, (-1)^{[t/T]} \left| \sin \frac{\pi t}{2T} \right| . \tag{37}$$

These solutions exhibit the dependence $1/r$, which is typical for standing spherical waves.

The solution for mass (36) shows that at a distance $r \ll \Lambda$ the time averaged distribution of mass of inertons along the radial ray, which originates from the particle, becomes

$$m \approx l_{\text{Planck}} \frac{m_0}{r} \tag{38}$$

In this region the tension (or rugosity) of space, as followed from expression (37), is: $\xi \approx 0$.

When the local deformation is distributed in space around the particle, it forms a deformation potential $\propto 1/r$ that spreads up to the distance $r = \Lambda$ from the particle's kernel-cell. *In the range covered by the deformation potential, cells of the tessel-lattice are found in the contraction state and it is this state of space which is responsible for the phenomenon of the gravitational attraction.* In terms of physics, the distribution (38) is replaced with the Newton's gravitational potential

$$U = -G \frac{m_0}{r} \tag{39}$$

where the gravitational constant plays the role of a dimensional constant.

An object, which consists of many particles (a solid, a planet, or a star), experiences vibrations of its entities (atoms, ions, particles). Entities vibrate in the neighborhood of their equilibrium positions and/or move to new positions. These amplitudes are de Broglie wavelength of entities. Hence the moving entities produce inerton clouds, which of course overlap. Due to the overlapping a total inerton cloud of the object [20] is formed. The spectrum of inertons is similar to the spectrum of phonons, as inertons immediately appear when entities move from their initial position, which is discussed in submicroscopic mechanics (we may say that a body of phonons is filled with inerton carriers). For instance, if we have a solid sphere with a radius R_{sph}, which consists of N_{sph} atoms, the spectrum of acoustic waves consists of $N_{\text{sph}}/2$ waves with the wavelengths $\lambda_n = 2an$ where a is the lattice constant (i.e. mid-distance between nearest atoms) and $n = 1,\ 2,\ 3,\ ...,\ N_{\text{sph}}/2$.

At the same time, inertons that accompany acoustically vibrating atoms produce also their own spectrum and the wavelengths of these collective inertonic vibrations can be estimated by expression

$$\Lambda_n = 2anc/\upsilon_{\text{sound}}. \qquad (40)$$

Also note that the behavior of these collective inerton oscillations obeys the law of standing spherical waves, i.e. the dependence of the front of the inerton wave must be proportional to the inverse distance from the source irradiating the wave, $1/r$. For instance, a solid sphere with volume 1 cm^3 includes around 10^{22} atoms; estimating the velocity of sound $\upsilon_{\text{sound}} \approx 10^3$ m/s and the distance between atoms 0.5 nm, we obtain for the amplitude of the longest inerton wave: $\Lambda_{N/2} \sim 10^{18}$ m. Thus, up to this distance the inerton field of the solid sphere is able to propagate in the form of the standing spherical inerton wave. To the solid sphere studied we may now apply the same consideration, which has been done above for the gravity of a particle. In particular, expression (39) is also applicable for the case of a massive object; at distance $r << \Lambda_{N/2}$, which for the solid sphere of volume 1 cm^3 is still a cosmic distance.

So, we are able to derive Newton's potential (39) also for a macroscopic object in terms of short-range action provided by inertons, carriers of mass properties of objects. Being averaged in time, a mass field around the object studied can be considered as a stationary gravitational potential. The availability of the tension/ruggosity around a massive object may be able to shed light on the problem of so-called 'dark matter', because places with a more or less significant value of the distortion of the tessel-lattice is quite possible. Hence a kind of a repulsion force, which is caused by a prolonged tension of space, can appear at the interaction of masses located in such places.

The theory presented sheds light on the principle of equivalence, which proclaims the equivalence of gravitational and inertial masses: $m_{\text{inertial}} = m_{\text{gravitational}}$. Namely, this equality, which is held in a rest-frame of the particle in question, becomes invalid in a moving reference frame. In the quantum context, this equality should be transformed to the principle of equivalence of the phases of gravitational and inertial waves. Because an averaged inerton filed of the object studied manifests itself as the object's stationary gravitational field. This correlation ties up the gravitational and inertial energies of the particle and also shows that **the gravitational mass is completely allocated in the inertial wave that guides the particle, or macroscopic object**. De Haas [21] was the first who came to this conclusion when comparing Mie's variational principle and de Broglie's harmony of phases of a moving particle. The exchange of mass and energy between a moving object and the tessel-lattice causes the induction of the gravitational potential in the range of spreading of the particle's/object's inertons.

Now let us consider the gravitational interaction between two objects taking into account the note of Poincaré [1] that an expression for the gravitation should include the velocity of the attractive object.

The sub-microscopic approach [22] points out to the fact that the gravitational interaction between objects must consist of two terms: (i) the radial inerton interaction between masses *M* and *m*, which results in the classical Newton gravitational potential energy

$$V_{\text{Newton}} = -G\frac{Mm}{r}, \qquad (41)$$

and (ii) the tangential inerton interaction between the central attracting mass *M* and the rotating attractable mass *m*, which is specified by the tangential component of the motion of the test mass *m*.

Indeed, components of the inerton's velocity in the vicinity of the particle, which moves with the velocity υ, are: υ along the particle path and *c* in the transversal directions (Figure 7). The same should take place for a moving macroscopic object, because of individual inerton clouds of vibrating entities in the object overlap forming a total inerton cloud (see Ref. 20 for details). In the total inerton cloud inertons migrate by the same rule, as is the case for inertons of a separate particle, i.e. they migrate far away of the object and then come back to it.

Now let this object with the mass *m* enveloped in its total inerton cloud rotates around the attracting mass *M*. The inerton cloud of the orbital mass *m* touches the central mass *M* and partly is absorbed by it, which results in the reciprocal interaction of masses *M* and *m.* Components of the velocity of this total inerton cloud are $\vec{c}$ along the radial line and $\dot{\vec{r}}_{\tan}$ in the tangential direction (Figure 8). Hence the total velocity of inertons in the total inerton cloud is $\hat{c} = \sqrt{c^2 + r^2\dot{\phi}^2}$ where we put for the tangential velocity $\dot{r}_{\tan} = r\dot{\phi}$. Then the kinetic energy of these inertons is $mc^2 \cdot (1 + r^2\dot{\phi}^2 / c^2)$. We may assume that this factor $1 + r^2\dot{\phi}^2 / c^2$ affects the classical Newton gravitational law (41), such that it is transformed to

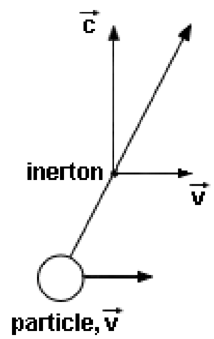

FIGURE 7. Moving particle and components of the velocity of one inerton from the inerton cloud (υ is the velocity of the particle in the current moment of time and *c* is the velocity of light).

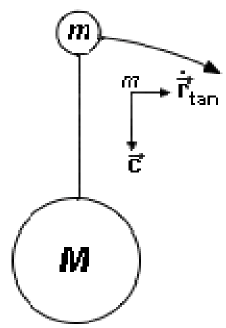

FIGURE 8. The scheme of the orbital motion of the test mass *m* around the central bigger mass *M*.

$$V_{\text{total}} = -G\frac{Mm}{r} \cdot \left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right). \tag{42}$$

The generalized formula (42) of Newton's gravitational law can be checked by applying for the description of those three phenomena that were described and predicted by the abstract formalism of general relativity, namely: 1) the motion of Mercury's perihelion; 2) the bending of light by the sun; 3) the gravitational red shift of spectral lines. Expression (42) allows us to examine the three problems in the framework close to that carried out in terms of classical physics, not general relativity. Expression (42) enables the immediate and easy derivation [22] of the same equations of motion for the three abovementioned problems that general relativity derived by using geodesic equations with complicated metric:

1) Motion of perihelion

$$I = mr^2\dot{\varphi},$$

$$E = \tfrac{1}{2}m\dot{r}^2 + \tfrac{1}{2}mr^2\dot{\varphi}^2 - G\frac{M\,m}{r} \cdot \left(1 + \frac{r^2\dot{\varphi}^2}{c^2}\right);$$

2) Bending of light

$$I = m\,r^2\dot{\varphi},$$

$$E = \tfrac{1}{2}m\,\dot{r}^2 + \tfrac{1}{2}m\,r^2\dot{\varphi}^2 - G\frac{M\,m\,r\dot{\varphi}^2}{c^2};$$

3) Red shift of spectral lines

$$E \cong \tfrac{1}{2} m l^2 \dot{\varphi}^2 - G\frac{Mm}{r} - G\frac{M\,m}{r} \cdot \left(-\frac{l\varphi^2}{2r} + \frac{l^2 \dot{\varphi}^2}{c^2} \right),$$

$$\nu \approx \left(1 - \frac{GM}{c^2 r} \right) \nu_0 \,.$$

Having exactly the same equations describing these three problems, we can follow the same classical solutions (see, e.g. Ref. 23) at the finding of the motion of perihelion, the bending of light and the red shift.

Therefore it does not make sense to use the complicated mathematics of general relativity to solve this or that challenge in the sky. The physics of the phenomena studied is hidden in the potential energy (42), which describes the interaction of two attracting objects.

The sub microscopic approach [22] to the description of macroscopic gravitation phenomena has disclosed that a point mass does not have any peculiarity in its metric; the point mass metric is the conventional Minkowski flat/linear-space metric. Only the orbital motion of a second test mass is able to alter the classical Newton gravitational potential energy (41) leading it to the generalized form (42). This linear metric disturbed by a smaller moving test mass changes to the Schwarzschild metric (or maybe another metric) in a range of space around these masses. An interesting conclusion can be withdrawn from the obtained results [22]: The sub microscopic consideration of gravity suggests no reasons to hypothesize a "black hole" solution at all. Only an outside source of the gravitational field is able to disturb the flat metric of a heavy central mass. So researchers dealing with the formalism of general relativity must be extremely careful in application of their theoretical studies to the description of the reality.

ELECTROMAGNETISM

The physical notion of elementary electric charge follows from a mathematical theory of the constitution of real physical space [24]. Set theory, topology and fractal geometry allow us to construct space, as a mathematical lattice of topological balls – the tessel-lattice that possesses fractal properties. A fractal volumetric deformation of a topological ball is associated with the notion of mass. A fractal surface deformation of a topological ball is associated with notion of elementary electric charge (Figure 9).

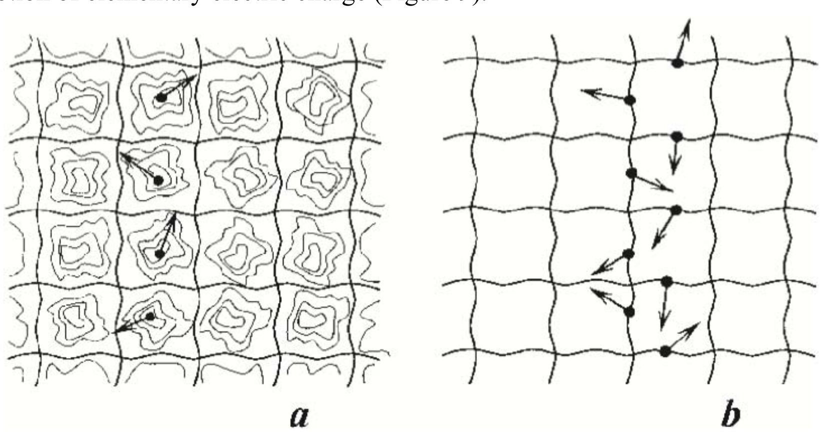

FIGURE 9. Two kinds of local fractal deformations in the tessel-lattice: volumetric (*a*) and surface (*b*).

In the degenerate tessel-lattice one can distinguish a middle radius of cells such that amplitudes of oscillations of the cells' surfaces (surface wavelets) cross the surface both out and in. Then the quant of surface deformation, when all amplitudes, i.e. needles, of the surface oscillations are directed outward of the cell can be associated with a positive electric charge. When all surface amplitudes, i.e. needles, are directed inward of the cell, the form can be called a negative electric charge (Figure 10).

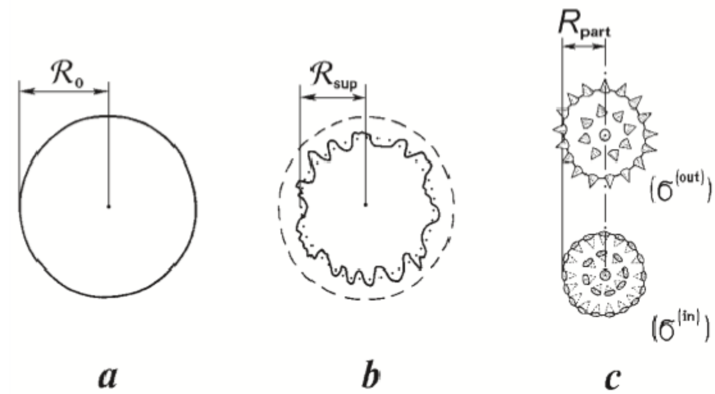

FIGURE 10. Completely free topological ball outside of the tessel-lattice (*a*); topological ball as part of the tessel-lattice, which can be referred to here as a superparticle (*b*); the formation of the charged particle (positive with amplitudes out and negative with amplitudes in) from the topological ball, or superparticle (*c*).

How many such amplitudes, or needles, cover the surface of a topological ball in the tessel-lattice? Obviously as many as the number of harmonics in the tessel-lattice. This number is defined by the quantity of balls that forms the tessel-lattice. Putting the middle size of a cell of the tessel-lattice equals the Planck's fundamental length, $l_{\rm Planck} \sim 10^{-35}$ m, and the radius of the visible universe $R_{\rm universe} \sim 10^{26}$ m, we can easily estimate the number of needles that cover the cell forming an elementary electric charge: $N_{\rm surface\ needles} \sim R^3_{\rm universe} / \ell^3_{\rm Planck} = 10^{183}$.

It is obvious that each *n*th small needle on the sphere surface can be regarded as the normal vector to the particle surface. If we designate the normal dimensionless unit vector as $\vec{u}$, the combination $\vec{u}\, h_0 / \eta$ can be interpreted as an elementary vector of the electric field, i.e. $\vec{\varepsilon}_{0n} = \vec{u}\, h_0 / \eta$. We may assume that the height of the needle can vary. In this case each of the needle states has its own surface stretched on the same base. Such kind of the needle motion is potential and hence all states of the needle surface can be described by a scalar function $\Phi_n(h)$. Then the field vector $\vec{\varepsilon}_n$ can be associated with the scalar function $\Phi_n(h) \propto h$, i.e. $\vec{\varepsilon}_n = -\nabla_h \Phi_n(h)$; so $\vec{\varepsilon}_n$ is a co-vector.

The spike of each *n*th needle is able to deviate from its equilibrium position, i.e., the bending of the needle from its axis must not be ruled out. The value of the displacement decreases from the spike to the base of the needle, which is fixed. Therefore this kind of motion can be related to a vector field (only the motion of a point is described by a vector). Let us designate this vector field as $\vec{A}_n$.

Let us write the Lagrangian density for the motion of the nth particle's needle and the nth cloud's needle taking into account their mutual interaction:

$$L_n = C\left\{\frac{1}{2}\dot{\Phi}_n^2 + \frac{1}{2}\dot{\vec{A}}_n^2 + \frac{1}{2}\dot{\varphi}_n^2 + \frac{1}{2}\dot{\vec{\alpha}}_n^2 - \upsilon_0(\dot{\Phi}_n \nabla \vec{\alpha}_n + \dot{\varphi}_n \nabla \vec{A}_n) - \upsilon_0^2 (\nabla \times \vec{A}_n)(\nabla \times \vec{\alpha}_n)\right\} \tag{43}$$

(C is a constant, its dimensionality in SI is kg/m^3). Here quadratic forms correspond to the kinetic energy of the fields Φ_n and $\vec{A}_n$ of the *n*th particle's needle and the kinetic energy of the corresponding fields ϕ_n and $\vec{\alpha}_n$ of the *n*th effective needle of the cloud.

The Euler-Lagrange equations with the functional derivatives are

$$\frac{\partial L_n}{\partial t}\frac{\partial L_n}{\partial \dot{Q}} - \frac{\delta L_n}{\delta Q} = 0, \qquad \frac{\delta L_n}{\delta Q} = \frac{\partial L_n}{\partial Q} - \frac{\partial}{\partial x}\frac{\partial L_n}{\partial\left(\frac{\partial Q}{\partial x}\right)} - \frac{\partial}{\partial y}\frac{\partial L_n}{\partial\left(\frac{\partial Q}{\partial y}\right)} - \frac{\partial}{\partial z}\frac{\partial L_n}{\partial\left(\frac{\partial Q}{\partial z}\right)}, \tag{44}$$

which results in wave equations of motion of the free charge:

$$\ddot{\Phi}_n - \upsilon_0^2 \nabla^2 \Phi_n = 0\,, \qquad \ddot{\vec{A}}_n - \upsilon_0^2 \nabla^2 \vec{A}_n = 0\,. \tag{45}$$

The considered motion can be depicted as shown in Figure 11.

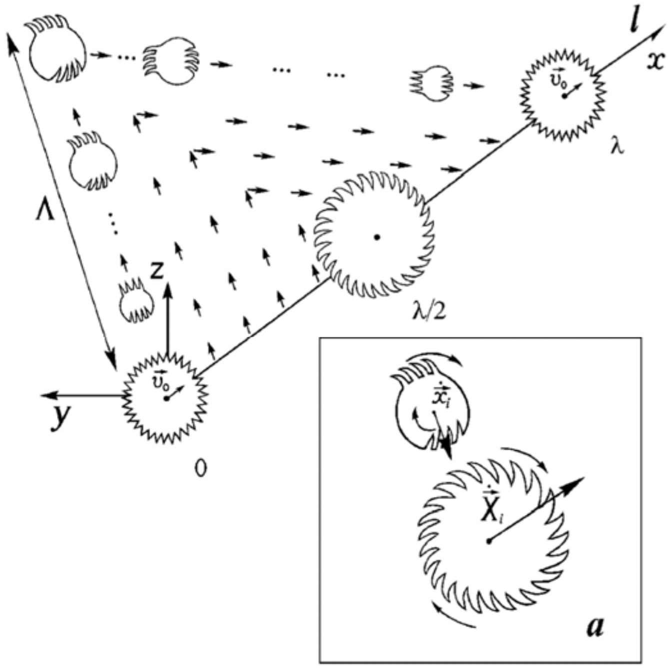

FIGURE 11. Diagram of the motion of the positive charged particle. The particle is accompanied by the cloud of electromagnetic polarized inertons, or inerton-photons, or simply photons (it is obvious that these particle's polarized inertons correspond to so-called "virtual photons" of quantum electrodynamics). (*a*) the moment of absorption of the *i*th inerton-photon by the particle.

We can see in Figure 11 that the electric state of the charged particle periodically changes to the magnetic state, i.e. the magnetic monopole state (in the place $\lambda/2$ of each de Broglie's wavelength, which all together form the whole particle path).

At last in standard symbols the Lagrangian density of the electromagnetic field that interacts with a charge takes the form

$$L_{\text{el. magn.}} = \frac{\varepsilon_0}{2c^2}\dot{\varphi}^2 + \frac{\varepsilon_0}{2}\dot{\vec{A}}^2 + \varepsilon_0 \dot{\varphi}\,\nabla\vec{A} + \frac{\varepsilon_0 c^2}{2}(\nabla\times\vec{A})^2\,\rho\,\varphi + \rho\,\vec{\upsilon}_0\vec{A}\,. \tag{46}$$

Note that the standard Lagrangian of the electromagnetic field does not contain $\dot{\varphi}$, because in classical and quantum electrodynamics they do not know in what way $\dot{\varphi}$ can be introduced.

Euler-Lagrange equations (44) based on the Lagrangian density (46) culminate in the Maxwell equations for the scalar φ and vector $\vec{A}$ potentials [24] (the so-called d'Alambert form):

$$\nabla^2\varphi - \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2} = \frac{\rho}{\varepsilon_0}\,, \tag{47}$$

$$\nabla^2 \vec{A} \quad \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2} = \quad \frac{\rho \upsilon_0}{\varepsilon_0 c^2}. \tag{48}$$

Eqs. (47) and (48) are the consequence of the conventional Maxwell equations if the electric field $\vec{E}$ and the magnetic induction $\vec{B}$ are associated with the potentials φ and $\vec{A}$ by relationships

$$\vec{E} = -\nabla \varphi - \frac{\partial \vec{A}}{\partial t}, \qquad \vec{B} = \nabla \times \vec{A}. \tag{49}$$

The behavior of a free photon has also been studied in detail [24].

An instantaneous photo of the photon (Figure 12): it is a cell of the tessel-lattice whose upper part of the surface is covered by needles that stick out of the cell and the lower part of the surface is covered by needles that stick inside of the cell. Each half a period $\lambda/2$ electrical polarization changes to the magnetic polarization (combed needles). The inerton is a basic spatial excitation, which migrates changing periodically its state between the mass μ_{inert} and the tension ξ_{inert} (Figure 12). An inerton dressed with the surface polarization becomes a photon.

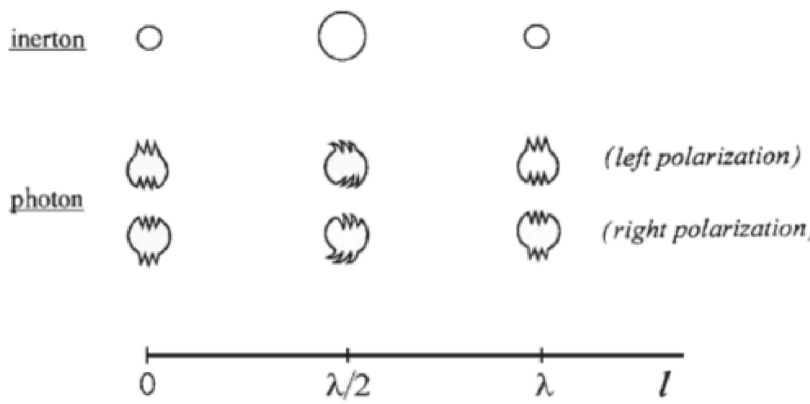

FIGURE 12. Two basic quasi-particles of the tessel-lattice: the inerton and the photon.

EXPERIMENTAL

In this section we focus on experimental testing of inerton fields in different physical, chemical physical and biochemical systems.

1. Owing to the overlapping of inerton clouds of vibrating atoms in a metal, those inertons should contribute to the effective potential of interaction of atoms in the crystal lattice. The possibility of separating this inerton contribution from the value of the atom vibration amplitude was studied in paper [25]. The experiment, which assumed the presence of the hypothetical inerton field, was performed [25]. We anticipated that the rotating Earth should generate the motion of inertons from the west to the east and also along the diameter of the globe. We made a simple resonator of inerton waves of the Earth whose geometry had to satisfy the following conditions: $2\pi R_{\text{Earth}} / (4 R_{\text{Earth}}) = \pi/2$, where R_{Earth} is the radius of the Earth.

To test the hypothesis, we put in such a resonator a razor blade and in 30 days later studied its morphological structure in an electron microscope. It was observed that the fine morphological structure indeed changed; a crude morphological structure remained the same [24]. Thus the expected changes in the structure of the test specimens caused by the inerton field were in fact convincingly fixed in micrographs.

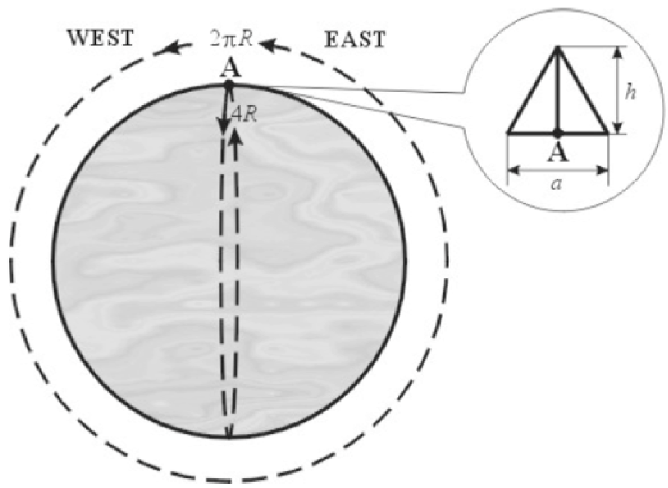

FIGURE 13. Inerton flows of the Earth (or the ether wind in the language of physicists of the 19th century) and the resonator of the Earth's inertons.

2. The two opposite concepts – multi photon and effective photon – readily describing the photoelectric effect under strong irradiation when the energy of an incident light is essentially smaller than the ionization potential of gas atoms and the work function of a metal were reconsidered from the viewpoint of the sub microscopic concept [26]. Taking into account that the electron is an extended object that is not point-like (owing to its inerton cloud whose size is known), the study of the interaction between the electron and a photon flux was carried out in detail. Laser pulses with intensity 10^{12} to 10^{18} W/cm^2 of low energy photons is able to ionize gas atoms, which was studied in many experiments. To describe the phenomenon, researchers concentrated on the multi photon concept by L. Keldysh (1964), which modified the simple photoelectric effect to a nonlinear consideration in which the atom is ionized by absorption of several photons. The *N*th-order time dependent perturbation theory changes the usual Fermi golden rule to *N*-photon absorption that produces a complicated expression for the probability w^N. However, in the 1970s E. Panarella stressed that many experiments could not be explained in the framework of the multi photon theory. The multi photon concept just failed to interpret fine details revealed in the experiments. E. Panarella suggested an effective photon concept in which *N* photons would gather together in a clump that bombard as a whole an atom ejecting photons. So, in Panarella's model the photoelectric effect became linear again. This concept could explain many experiments carried out both in gases and metals.

The submicroscopic concept started from an idea that electrons in atoms or in a metal should be treated as extended objects, but not point-like: an electron together with its inerton cloud has the length equal to their de Broglie's wavelength λ and the electron's inerton 'wings' spread up to the distance $\Lambda = \lambda c / \upsilon_0$ in transversal directions around the particle. Hence, the cross-section of the electron's inerton cloud: $\Lambda \lambda \approx 100$ nm^2 (because the velocity of electrons is around $3 \cdot 10^6$ m/s). Thus, such an object is able to absorb *N* photons simultaneously, which can be considered an anomalous photoelectric effect. The corresponding probability was calculated and applied to describe tens of different experiments on generation of photoelectrons in gases and a metal. The results are completely satisfactory. Indeed, if the intensity of a laser pulse 10^{16} to 10^{18} W/cm^2, we can estimate a mean distance between photons in the flux of laser pulse as $d \approx 3$ to 4 nm. Then the number of photons (yellow points and arrows in Figure 14), which bombard the electron's inerton cloud is: $\Lambda \lambda / d^2 \sim 10$. In other words, the size of the electron (jointly with its inerton cloud) is large enough and can absorb up to 10 photons from a laser flux simultaneously. The total energy of these 10 photons exceeds the ionized potential of atoms in a gas (or the work function in a metal).

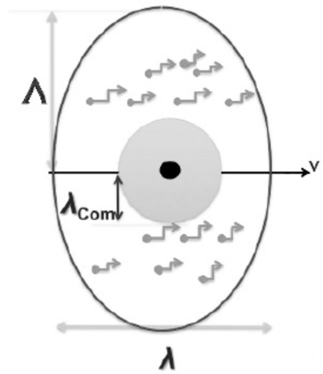

FIGURE 14. The picture above shows the electron surrounded by its cloud of inertons.

3. The phenomenon of the diffraction of photons is explained [27] naturally without involving a vague "wave-particle". It is well known that photons coming through a transparent media generate non-equilibrium phonons whose lifetime varies from $\tau \approx 10^{-11}$ to 10^{-9} s. After that non-equilibrium phonons disappear and the corresponding inerton clouds that accompanied those phonons fly away in transversal directions. During a short time, the damping phonons gradually release inertons in transverse directions to the phonon's wave vector $\vec{K}$, which is practically parallel to the photon beam's path. So, these inertons move almost perpendicular to the beam of photons and hence can tangibly affect the photon trajectories.

Let t be a time interval between subsequent fronts of incident photons. If the inequality $t < \tau$ holds, the second photon will arrive to the interferometer at the moment when inertons generated by the first photon are still available in the interferometer. These inertons deviate the second photon, such that it forms the second ring of the diffraction pattern. Similarly for the third photon, etc. However, in the case of the inequality $t > \tau$ (this corresponds to the lowest intensity of photons $N \approx 10^4$ photons/sec reached by E. Panarella in his experiments) the second photon does not experience a transverse action and continues to follow its path to the central peak on the target. Hence the mechanism described is capable to account for Panarella's experiments in which the diffraction fringe was absent.

4. The behavior of the subsystem of hydrogen atoms of the $KIO_3{\cdot}HIO_3$ crystal, whose IR absorption spectra exhibit equidistant submaxima in the vicinity of the maxima in the frequency range of stretching and bending vibrations of OH bonds was studied in paper [28]. It was shown that hydrogen atoms co-operate in peculiar clusters in which, however, the hydrogen atoms did not move from their equilibrium positions but vibrated synchronously. The interaction between the hydrogen atoms is associated with the overlapping of their matter waves, i.e. inertons. The exchange by inertons results in the oscillation of hydrogen atoms in clusters, which emerges in the mentioned spectra. The number of atoms, which compose the cluster, was calculated and the spectrum of such cluster was computed. Theoretical curves show that the cluster state of hydrogen atoms features sub maxima that are very close to the appropriate experimental maxima.

5. Electron clusters, X-rays and nanosecond radio-frequency pulses were produced by 100 mW continuous-wave laser at the illumination of ferroelectric crystal of $LiNbO_3$ [29]. A long-living stable electron droplet with the size of about 100 μm and velocity ~ 0.5 cm/s moved freely in the air near the surface of the crystal, experiencing the Earth gravitational field. The microscopic model of cluster stability, which is based on submicroscopic mechanics, was suggested. It was assumed that the laser beam knocked not only photoelectrons, but also inertons from the crystal. Inertons were knocked out from overlapping inerton clouds of atoms that form the crystal lattice. Therefore, knocked photoelectrons surrounded by knocked inertons become unstable to the formation of a cluster. In the cluster, the role of a restraining force played the inerton field, a substructure of the electrons' matter waves, which could elastically withstand the electrons' Coulomb repulsion. It was shown that electrons in the droplet are in fact heavy electrons whose mass at least 1 million times exceeds their rest mass. Their mass has increased owing to the absorption of inertons ejected from the crystal by laser.

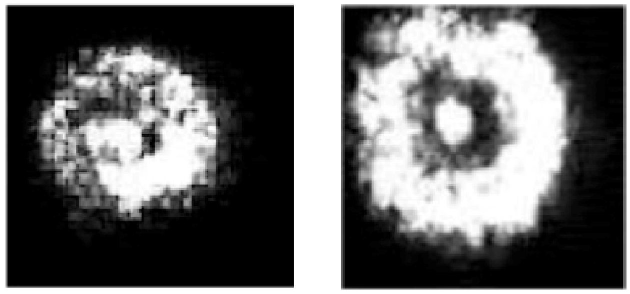

FIGURE 15. Specular reflected beam with a ‘droplet’ (separated by 1 sec) from the video.

6. In paper [30] it was studied the behavior of the permittivity of such liquid systems, as pure distilled water, alcohol and 50%-aqueous solutions of alcohol, as affected by the inerton field generated by a special signal generator contained within a wrist-watch or bracelet made by so-called Teslar technology. It was found that the changes were significant. The method employed allowed us to fix the value of frequency of the field generated by the Teslar chip. The frequency was determined to be approximately 8 Hz. The phenomenological consideration and submicroscopic foundations of a significant increase of the permittivity were studied taking into account the inerton field produced by the Teslar chip. Inertons significantly changed the interaction between polar water molecules. Namely, absorbed inertons showed the phenomena of “freezing” of water molecules, as the mobility of water molecules was strongly suppressed. The samples studied represented a mixture of water and alcohol: 50% of water and 50% of alcohol. With time alcohol evaporated and the capacity of samples dropped. This can be seen on the left graph of Figure 16. However, when a Teslar chip was approaching the cuvette, the inerton field of the chip strongly damped the movement of water and alcohol molecules, which also decreased the capacity of the sample; this is seen in the right graph of Figure 16.

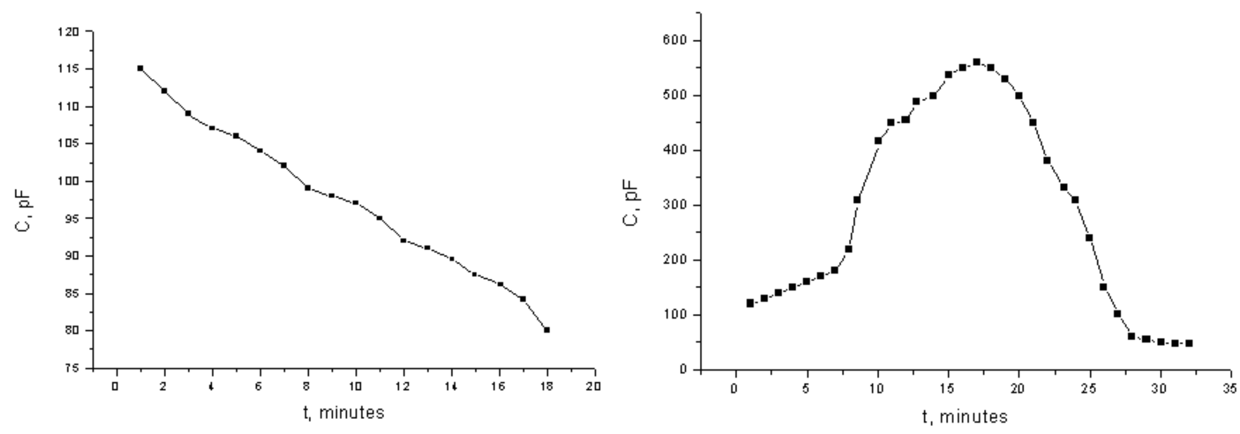

FIGURE 16. Capacity of the water solution with alcohol (50% : 50%). The left graph shows measurements without application of the inerton field. The right graph depicts measurements of the solution affected by the inerton field.

An influence of inerton fields on aqueous solutions of L-tyrosine, b-alanine and plasma extracted from the blood of a patient with heart vascular disease changes was studied by using holographic interferometry [31]. We showed that the refraction index of degassed pure distilled water and aqueous solutions of L-tyrosine and b-alanine affected by the inerton field of a Teslar chip does not change during the first 10 minutes of influence. In contrast, a 1% aqueous solution of the plasma changes the refractive index when affected by inerton fields. The characteristic time of reaction is about 100 seconds. In the photograph below the dynamics of the fringe pattern of the aqueous solution of plasma of human blood affected by 2 Teslar chips is presented. The strong disturbance of the optical density of the solution emerges already after 72 s (Figure 17).

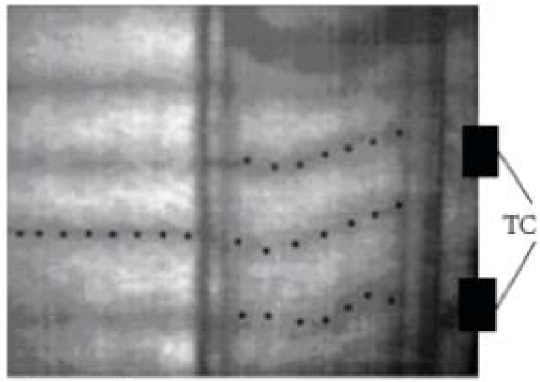

FIGURE 17. Dynamics of the fringe pattern of the aqueous solution of plasma of human blood after the insertion of two Teslar chips. The strong disturbance of the optical density of the solution is emerged already in 72 s.

7. The coherent emission and absorption of inerton clouds by nearest atoms supply deeper information on Bose-Einstein condensation of cool atoms [20]. The point is that a Bose-Einstein condensate cluster can be treated not only as a whole continuous object, which is described by a unified wavefunction ψ, but also as a dynamic system of many coherently oscillating entities, like a nucleus that consists of many nucleons. Such approach would bring some new results in the description of Bose-Einstein condensates, the more so that it is completely deterministic owing to carriers, i.e. inertons, which establish a short-range interaction between entities.

Emission and re-absorption of inertons by entities means that the mass of atoms in any substance is not a stationary parameter, but dynamic. The value of mass varies with an amplitude Δm that is small in comparison with the rest mass of the atom. However, the inerton field can be excited in some substances and is able to affect other substances inducing novel effects: change in mass rearranges entities, which tends to a peculiar secondary phase transition in the substance in question, namely, clusters. The phenomenon can be understood from the following consideration. In a molecular liquid the intermolecular interaction can be modeled by a Lennard-Jones potential $U_0 = -\varepsilon_1 / r^6 + \varepsilon_2 / r^{12}$. However, as was shown [20], vibrations of entities at their equilibrium positions should add one more term to this potential, namely, associated with the vibration energy (owing to of the overlapping of inerton clouds of entities). Hence, the corrected intermolecular potential becomes

$$U = -\varepsilon_1 / r^6 + \varepsilon_2 / r^{12} + \tfrac{1}{2}\gamma r^2 . \qquad (50)$$

A solution of the equation $\partial U / \partial r = 0$ gives a stable equilibrium distance r_0 between molecules. A correction on the side of the third term from expression (50) to r_0 is rather small and can be neglected. However, in the presence of outside inerton fields the third term in (50) can increase significantly, such that its contribution to the solution of the equation $\partial U / \partial r = 0$ will be substantial. This means that the substance affected by inertons will have a secondary phase transition: its molecules will rearrange, as the equilibrium distance between molecules changes from r_0 to $r_0 - \delta r$. As a result, we obtain very new properties in the substance studied and even at special conditions we obtain new chemicals [20]: we observed a fast production of biodiesel (methyl trasnesterification) in the study of mixture of oil and methanol. For example, Figure 18 shows changes in the viscosity of the bentonit (a sort of a clay that can be used as a sorbent); these experiments have been recently conducted in our laboratory.

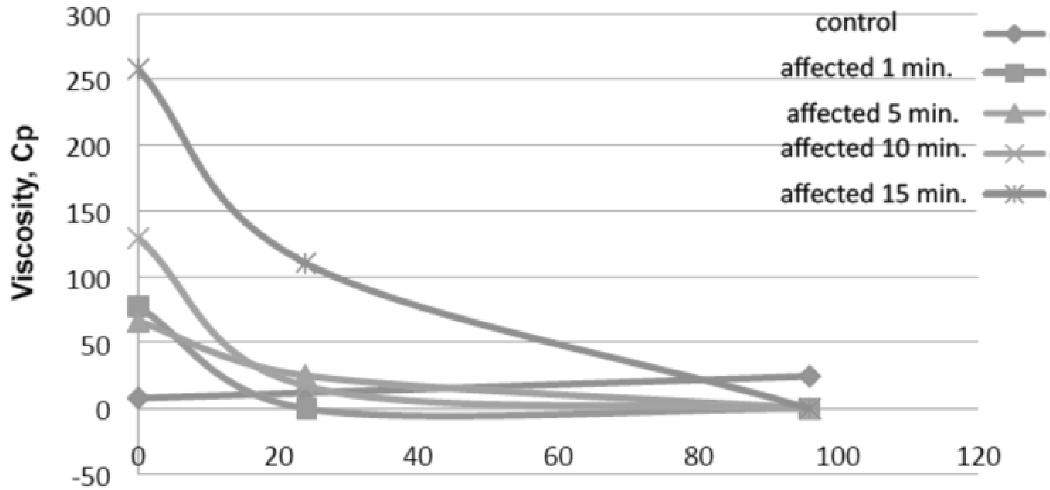

FIGURE 18. Behavior of the viscosity of the bentonit affected by the inerton field at different expositions (viscosity vs. hours). The irradiation during 15 minutes increases the viscosity of the bentonit up to 250 times!

CONCLUSION

The theory of real space, as a tessellation lattice of primary topological balls, allows the derivation and the determination of all the fundamental physical parameters, such as mass, particle, motion, time, charge, monopole, lepton, quark, de-Broglie wavelength, Compton wavelength, spin, etc. The introduction of the notion of motion is equivalent to the appearance of time, which is in line with de Beroglie remark that physics means motion. The notion of a massive particle is associated with a fractal volumetric deformation of a cell of the tessel-lattice. The motion of such a particulate cell is accompanied by the motion of spatial excitations called *inertons* that migrate by a relay mechanism, i.e. hopping from cell to cell. Inertons carry fragments of the particle's velocity and mass and are responsible for the uncommonness of quantum mechanics and the phenomenon of the gravitational attraction. Grand authorities, whose work formed the basis of the sub microscopic concept presented here were three great French scientists: Henri Poincaré (topology of space and the aether, which was separated from the notion of space yet, but in which particles moved surrounded by the aether's excitations), Louis de Broglie (a moving particle is guided by a real wave whose origin is in a sub-quantum medium and such motion generates relationships $E = h\nu$ and $p/h = \lambda$) and Michel Bounias (the constitution of mathematical space as such, and the construction of the physical space as a consequence of mathematical space). In the submicroscopic concept the de Broglie wavelength λ is interpreted in relation to the spatial period of a moving particle. Within the section λ, due to the emission and re-absorption of the particle's inerton cloud, parameters of the particle undergo periodical changes:

velocity $\upsilon_0 \to 0 \to \upsilon_0$; mass $m \to 0 \to m$ and the tension $0 \to \xi \to 0$; electric charge $e \to 0 \to e$ and the magnetic charge, i.e. monopole state $0 \to g \to 0$; particle shape: beanlike $\to$ spherical $\to$ beanlike (such internal motion manifests itself in conventional quantum mechanics as a half-integer spin).

The submicroscopic concept of the physical world presented in this work supposes a complete deterministic description of the quantum system studied, which enables us to cast a glance at the science behind the pattern constructed by conventional quantum physics. The dynamic inerton field induces the phenomenon of gravity rather than the static geometry of empty space-time as general relativity orders. In such a manner, the inerton field should be considered as a source of gravitation phenomena.

As the inerton field is dynamics, it realizes the interplay between objects by means of inerton waves. This signifies that everyone emits his/her inerton waves and hence the waves overlap with those or other individuals. Consequently, we may conclude that the inerton field influences our live, activity, consciousness, and mind since our own inerton fields emitted at the brain neuromediator interactions overlap and form the entire mental network of the Earth; we are able to communicate each other by this field via the perceptive channel. Thoughts and feelings are full components of universe, but while emotional feelings do not deserve to be justified, they may have a physical impact in terms of inerton waves, which are a particular kind of space fractal deformation accompanying any motion of particle-like structures. Because any feeling is at least supported by a cascade of molecular interactions between brain cortex and limbic system, thoughts may have physical effects independently from the actions they elicit.

Thus effects induced by inerton fields in condensed media are quite important and, therefore, further studies of these fields and their interaction with substances promise the discovery of new physical phenomena and open a gateway to new advanced technologies.

ACKNOWLEDGMENT

I am thankful to Dr. Richard Amoroso for the invitation to participate in the 7th Vigier Symposium (Imperial College, London, July, 2010) at which this talk was presented.

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