ON THE NATURE OF
THE ELECTRIC CHARGE

Volodymyr Krasnoholovets

Institute for Basic Research
90 East Winds Court, Palm Harbor, FL 34683, U.S.A.
Home Page http://www.inerton.kiev.ua

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Abstract

The geometry of the elementary charge is studied in the framework of the concept of space considered as a tessellated lattice ('tessellattice'), which has recently been developed by M. Bounias and the author. The descriptive-geometric sense of the electric and magnetic fields and their carriers – photons – is analyzed. The notion of the scalar and vector potentials of a charged particle and their behavior at the motion of the particle along a path is investigated in detail. Based on the potentials, the Lagrangian leading to the Maxwell equations is constructed. The distinctive properties of the inerton and the photon – two basic elementary excitations, or quasi-particles of the space tessellattice – are discussed. Summarizing, we may say that the work suggests the detailed interpretation of the Maxwell equations in terms of the submicroscopic approach to Nature.

Key words: space, tessellattice, electric charge, Maxwell equations, photon, inerton

PACS: 01.55+b General physics; 03.50De Classical electromagnetism, Maxwell equations; 11.90+t Other topics in general theory of fields and particles

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The electric charge is kept and
plays on the surface of a particle.

The R̥gveda, 1.28.9; 9.65.25; 9.66.29

1. INTRODUCTION

A very abstract and formal nature of modern schemes of geometrization of
fundamental physical interactions is a matter of common knowledge. Among
such kinds of approaches there are schemes of grand unification of electromag-
netic, weak and strong interactions, theories of string, superstring and super-
gravity, etc. In these theories the description of sources of fields – the mass and
the electric charge – is realized by means of abstract classical or wave fields of
an indeterminate nature (but fundamental as are suggested!) with a respective
statistical interpretation. One points out here only some of the approaches [1-8].
A mathematical model (field presentation) of a single photon as a real finite ob-
ject has been developed in papers [9]. We should point out an interesting model
by Hofer [10] aimed at the description of the electromagnetic field to so-called
natural units in the framework of which the electric field and the vector poten-
tial change their dimensionality to typical mechanical units. Recently, models of
charged particles that are characterized by appropriate electromagnetic clouds,
Bagan *et al.* [11], or clouds of soft photons, Greenberg [12], have been proposed;
in those models infrared divergences disappear just due to the original dressing
of particles. Todorov [13] treated electrical charges as something that followed
from the gauge-invariant Dirac and Klein-Gordon equations. Regarding the fur-
ther investigation of the Maxwell equations we may point out in particular an
approach by Drummond [14] aimed at interchanging the magnetic and electric
variables and the formation of the common complex variable.

However, it must be emphasized that the mentioned models and all other ones
of quantum electrodynamics determine photons and consider their interaction
with particles only in abstract phase spaces such as the momentum one, but not
in the real space.

At the same time the structure of the real physical space considered as a
structured vacuum, a quantum aether, or a space net on the background of which
all physical processes take place has come under the scrutiny of science in the last
decade (see, e.g. Refs. [15-20]). Specifically, in the author's works [19-23] there
have been developed a concept that makes it possible to look at the notion of mass

and the motion of a massive particle from the other viewpoint that fundamentally differs from standard field approaches. The further development has allowed the deriving the macroscopic gravitation from submicroscopic first principles [24,25].

It turned out that the author's approach was in excellent agreement with the pure mathematical research of the construction of space carried out by Bounias and Bonaly [26], and Bounias [27]. This allowed M. Bounias and the author joined forces in order to develop founding principles about mathematical constitution of space [28] and then to construct the physical space, i.e. to derive matter and physics laws from the constitution of space and combination rules permissible by the space [29]. In these works we start from set theory, topology and fractal geometry and has shown that the real space-time is characterized by a topologically discrete structure. An abstract lattice of empty set cells accounts for a primary substrate in the real physical space. Space-time is represented by ordered sequences of topologically closed Poincaré sections of this primary space with a lattice structure called the 'tessellattice'. The interaction of a moving particle-like deformed cell with the surrounding tessellattice involves a fractal decomposition process that supports the existence and properties of previously postulated inerton clouds as associated to particles.

We have shown [29,30] that if a deformation of primary cells involves a fractal transformation to objects, there occurs an alteration in the dimensionality of the cell(s) and the homeomorphism is not conserved. In this event the fractal kernel stands for a particle state and the reduction of the corresponding volume of the cell is compensated by morphic changes of surrounding cells. The fractality is specified by quanta and combination rules [30] that determine oriented sequences with continuity of set-distance functions providing a space-time-like structure that facilitates the aggregation of the mentioned deformations into fractal forms standing for massive objects. An appropriate dilatation of space is induced outside the aggregation. At a submicroscopic scale the families of fractal deformations produce families of particle-like structures, but at large scale an apparent expansion has to occur.

It has been argued [22] that the size of a primary cell of the space tessellattice is probably on the order of 10^{-30} m (it is the scale at which, according to the theory of grand unification of interactions, all types of interactions should coincide). In a flat, or degenerate space all cells, or superparticles, are found in a state degenerated over all multiplets and can be characterized by a mean volume $\mathcal{V}_{\text{sup}}$. The creation of a mass particle means the change in the initial volume of the correlative superparticle, i.e. $\mathcal{V}_{\text{sup}}$ passes to the other fixed value $\mathcal{V}_{\text{part}}$ and

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the rest mass of the particle is determined as $M_0 \propto \mathcal{V}_{\text{sup}}/\mathcal{V}_{\text{part}}$. A detailed study on the generation of mass in a cell of the tessellattice has been performed in Refs. [29,30] in which we have shown that the mass of a particle is a function of the fractal-related decrease of the volume of the cell,

$$M \propto \frac{1}{\mathcal{V}_{\text{part}}} \left(e_\nu - 1 \right)_{e_{\nu \geq 1}}$$

where (e) is the Bouligand exponent, and (e−1) is the gain in dimensionality given by the fractal iteration. Just the volume decrease is not sufficient for providing a cell with mass, because a dimensional increase is a necessary condition.

As has been shown in Ref. [24], a moving particle constantly exchanges by mass with the particle's inertons: the inert mass of the particle $M_0/\sqrt{1 - v_0^2/c^2}$ is periodically dissociated to M_0 (on each odd segment of the particle path $\lambda/2$ where λ is the particle's de Broglie wavelength) and then the particle re-absorbs inertons (on each even segment $\lambda/2$ of the particle path) and its mass is restored to $M_0/\sqrt{1 - v_0^2/c^2}$. Thus gravitons of the general theory of relativity (which are not a realistic solution [31, 32]) give way to inertons.

The existence of inertons was demonstrated in papers [32-34]. Because of that it is quite reasonable to attempt to extend the author's concept and study how an electric charge appears in the canonical elementary particle within the framework of the space tessellattice and how the charge moves dressed by a cloud of elementary excitations that carries both inert and electromagnetic properties. Account must be taken of the fact that the motion of the charge should be coordinated with all the aspects of electrodynamics. And the first step on the road to such a theory has already been made [35]: the photon allows an interpretation of an excitation migrated in a discrete space, i.e. the tessellattice.

It is well known that atoms in a crystal, in view of interaction, are found in the uninterrupted collective motion. When this is the case, each of atoms has as many non-equivalent wave vectors as there are atoms in the crystal lattice (see, e.g. Ref. [36]). Let us transfer this property to the space tessellattice, especially as in Ref. [30] we have shown that topological structures available at elementary scales can be distributed down to cosmic scales. In particular, this is true for the topological notion of the charge formed when a quantum of fractal deformations collapses into one single cell: the concavity may be determined as the negative charge and the convexity may be defined as the positive charge.

Before going into the further development of topological details pertinent to the charge construction and its behavior, we first of all should construct a simple

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physical model of the charge in the space tessellattice employing conventional mathematics. Let us try to do that in the present work.

2. COLLECTIVE BEHAVIOR OF SUPERPARTICLES

Let $\mathfrak{N}$ be the quantity of cells (or superparticles, in other words) that the whole space tessellattice contains. Of course the value of $\mathfrak{N}$ is inconceivable huge. Nonetheless it can be roughly estimated. The size of the observed part of the universe is on the order of 10^{26} m (see, e.g. Ref. [37]). The superparticle size has been estimated as 10^{-30} m. Therefore, $\mathfrak{N} \sim (10^{26}\text{m})^3/(10^{-30}\text{m})^3 = 10^{168}$.

The availability of direct contact between neighboring superparticles means that they are characterized by a coupling energy. Such kind of a connection brings into existence collective vibrations of superparticles and hence each of superparticles is influenced by remained $\mathfrak{N} - 1$. The vibration process lies in the fact that centers of equilibrium positions of superparticles vibrate with amplitudes a_n $(n = 1, \mathfrak{N}/2)$ and each of the superparticles takes part in $\mathfrak{N}$ different vibrations simultaneously. When superparticles are in contact, the volume $\mathcal{V}_{\text{sup}}$ of a degenerate superparticle should be smaller than the volume $\mathcal{V}_0$ of an absolutely free superparticle, which is reached when the superparticle is removed from the space tessellattice. Let the rest mass of the superparticle (i.e. degenerate superparticle) in the tessellattice be defined as $\mathcal{M}_{\text{sup}} \propto \mathcal{V}_0/\mathcal{V}_{\text{sup}}$. In this case $\Delta\mathcal{M}_{0,\text{sup}} \propto \mathcal{V}_0 \times (1/\mathcal{V}_{\text{sup}} - 1/\mathcal{V}_0)$ can be called the superparticle's defect mass produced by the coupling. To regard space as the zeroth vacuum (in terms of quantum field theory), one needs to consider the mass $\mathcal{M}_{\text{sup}}$ as a frame of reference of all massive excitations including particles. In other words, we may put $\mathcal{M}_{\text{sup}} = 0$ for the ground level and then all masses of quasi-particles and particles excited in the tessellattice should be count off from that.

Another kind of vibrations may also be originated in the tessellattice and this kind of vibrations is not typical for atoms of the crystal lattice. In the presence of direct contact of the superparticle surfaces one can presuppose that the collective behavior of these surfaces should occur. According to what has been said, Fig. 1 shows states of vibrations of superparticles in the space tessellattice. In Fig. 1 a the center of gravity of each elementary cell vibrates at the equilibrium position. In Fig. 1b the cellular structure is considered as a network and each elementary link of the network vibrates at its equilibrium position.

It is natural to assume that the reduction of the superparticle volume from $\mathcal{V}_0$ in the free state to $\mathcal{V}_{\text{sup}}$ in the degenerate state of the space (i.e. in the
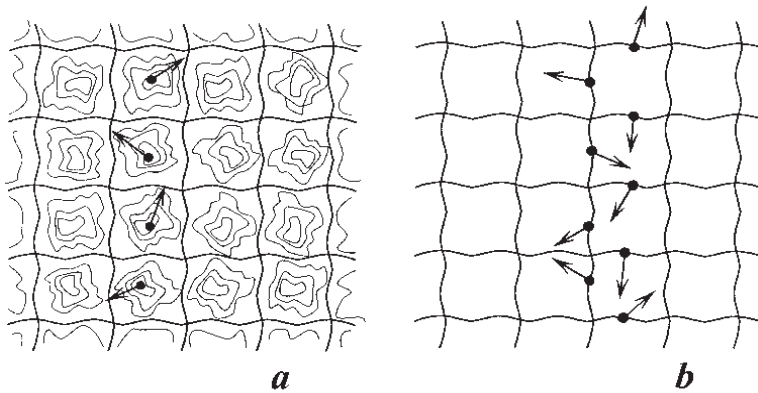
Figure 1: Two kinds of superparticle vibrations in the degenerate space: (a) vibrations of the center-of-mass of superparticles; (b) vibrations of the surface of superparticles.

tessellattice) takes place along with the conservation of the general area of the superparticle's surface. Let $\mathcal{R}_0$ and $\mathcal{R}_{\text{sup}}$ be typical radii of the same superparticle in the free state and in the tessellattice, respectively. Then one can write the relation

$$4\pi\mathcal{R}_0^2 = 4\pi\mathcal{R}_{\text{sup}}^2 + \Delta S \tag{1}$$

where the defect of surface ΔS of the superparticle can probably be found in the state of a collective motion of fractal elements. The above can schematically be shown in Fig. 2. Here the defect of surface ΔS consists of the whole set of fractal elements σ_n (or amplitudes of the surface vibrations) that cross inside and outside the surface formed by the radius $\mathcal{R}_{\text{sup}}$, such that $\Delta S = \sum_{n=1}^{\mathfrak{N}} \sigma_n$. It is precisely these surface vibrations that can be associated with fluctuations of the electromagnetic field and the electric charge. Indeed the orientation of the surface amplitudes σ_n inside of the superparticle (i.e., inside the sphere limited by the radius $\mathcal{R}_{\text{sup}}$) we interpreted [29,30] as a quantum of fractal deformations collapsed into one cell (the negative charge) and the surface amplitudes σ_n oriented outside the surface of the superparticle is a quantum of fractal deformations, which forms the positive charge. Thus we may conjecture that each amplitude σ_n oriented inside a superparticle describes the negative element of the electric field and σ_n oriented outside of a superparticle depicts the positive element of the electric field. Evidently, in the average the degenerate space must be electro-neutral.
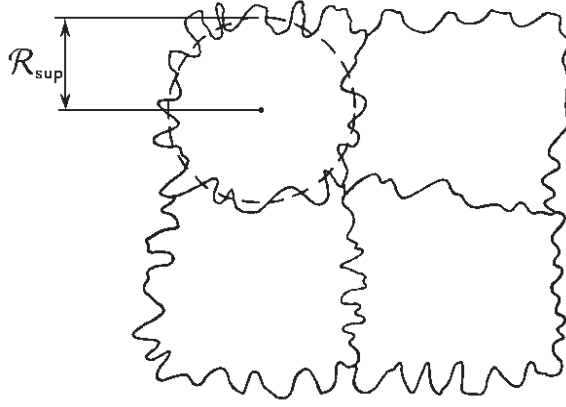
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Figure 2: Schematic presentation of collective vibrations of the surfaces of superparticles in the degenerate space (in other words, these are homeomorphic transformations of space elementary cells).

Therefore the sum of the amplitudes oriented towards the inside of the superparticle surface has to be equal to the sum of the amplitudes oriented towards the outside, $\sum_n \sigma_n^{(\text{in})} = \sum_n \sigma_n^{(\text{out})}$.

Thus we arrive at the following statement, or axiom:

Axiom. The total surface of a superparticle, whatever transformations of the superparticle may occur, should be invariant.

3. GEOMETRY OF THE CHARGE

The surface defect ΔS of a particle may consist of exclusively unidirectional amplitudes $\sigma_n^{(\text{out})}$ or $\sigma_n^{(\text{in})}$. That is why the transformation of a superparticle to the positive charge can be presented as follows

$$4\pi \mathcal{R}_0^2 = 4\pi R_{\text{part}}^2 + \sum_{n=1}^{\mathfrak{N}} \sigma_n^{(\text{out})}; \tag{2}$$

a similar relationship is true for the negative charge (i.e., when all amplitudes σ_n are $\sigma_n^{(\text{in})}$). In view of the fact that the elementary charge is characterized by the central symmetry one can suggest that all the amplitudes σ_n in (2) are identical
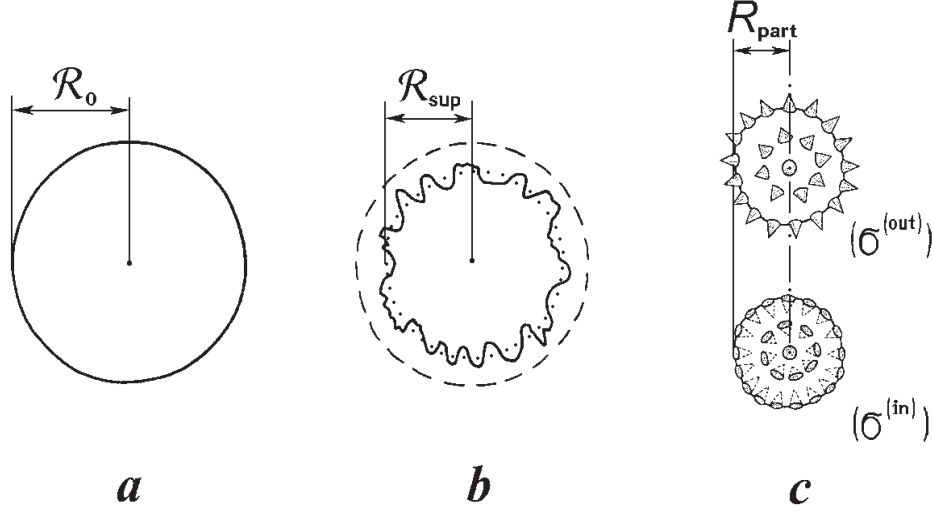
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Figure 3: Transitions of the superparticle from the free state (a) to the degenerate state in the space tessellattice (b) and then to the state of the charged particle, either positive or negative (c).

in value. By setting $\sigma_n = \sigma$ (here $\sigma \equiv \sigma^{(\text{out})}$ or $\sigma \equiv \sigma^{(\text{in})}$) one rewrites (2) in the form

$$4\pi \mathcal{R}_0^2 = 4\pi R_{\text{part}}^2 + \mathfrak{N}\sigma. \tag{3}$$

In particular, formula (3) should be justified for leptons (e, μ, τ): with gradual increase of the mass $M_e < M_\mu < M_\tau$, the radius must decrease ($R_e > R_\mu > R_\tau$) and the surface amplitude must increase ($\sigma_e < \sigma_\mu < \sigma_\tau$). Transitions of the superparticle from the free state to the degenerate state in the tessellattice and then to the state of a particle are schematically shown in Fig. 3.

Let us study the possibility of representing the surface defect ΔS in the form shown in Fig. 3 c, which can be called the "chestnut" model. In other words, the chestnut model means that the particle is presented by a sphere with needles that stick out (or inside) of the sphere surface.

Let the shape of the surface needle be defined by the figure of rotation of the function

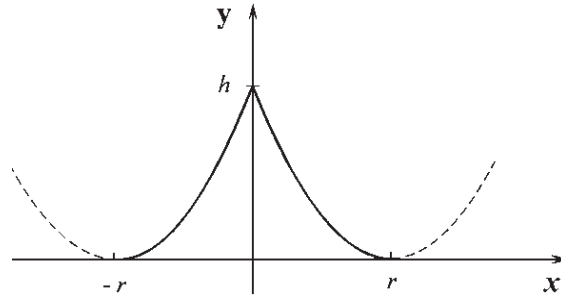$$y = h \cdot \left(\frac{x}{r} - 1\right)^2 \tag{4}$$

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Figure 4: Graphic display of the function (4).

that revolves around the OY axis, see Fig. 4 (another shape of the needle is studied in Appendix). Here h is the height of the needle and r is the radius of the base of the needle. Then the area of surface of the needle is

$$\sigma_{\text{needle}} = 2\pi \int_0^h x(y)\ dl = 2\pi \int_0^h r\Big(1 + \sqrt{1 + \frac{y}{h}}\ \Big)\sqrt{1 + \frac{r^2}{4hy}}\ dy$$

$$= \frac{\pi r^4}{6h^2}\Big[\Big(1 + \frac{4h^2}{r^2}\Big)^{3/2} - 1\Big]$$

$$+ \frac{\pi r^3}{2h}\Big[\frac{2h}{r}\sqrt{1 + \frac{4h^2}{r^2}} + \ln\Big(\sqrt{1 + \frac{4h^2}{r^2}} + \frac{2h}{r}\Big)\Big]. \qquad (5)$$

Now we can write the total area of the particle surface:

$$S = 4\pi R_{\text{part}}^2 - \mathfrak{N}\sigma(r) + \mathfrak{N}\sigma_{\text{needle}} \qquad (6)$$

where

$$\sigma(r) = 2\pi R_{\text{part}}^2\Big(1 - \cos\frac{r}{R_{\text{part}}}\Big) \qquad (7)$$

is the area of the needle base (i.e. circle) on the sphere with the radius R_{part} [38]; it is obvious that the value of $\mathfrak{N}\sigma(r)$ must be excluded from the the surface defect ΔS. Note that the part of the particle surface, which is not overlapped by the needle bases (7), is neglected. Since $r \lll R_{\text{part}}$, one can reduce expression (7) to $\sigma(r) \simeq \pi r^2$. Then in this case Eq. (6) due to the axiom of the surface invariant is reduced to

$$S = 4\pi R_{\text{part}}^2 + \Delta S, \qquad (8)$$

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$$\Delta S \;=\; \mathfrak{N}\pi\left\{\frac{16\,r^4}{h^2}\left[\left(1+\frac{4h^2}{r^2}\right)^{3/2}-1\right]\right.$$

$$\left.+\;\frac{r^2}{2h}\ln\left(\sqrt{1+\frac{4h^2}{r^2}}+\frac{2h}{r}\right)+r^2\sqrt{1+\frac{4h^2}{r^2}}-r^2\right\}. \tag{9}$$

Let us look into the possibility of the extreme of the surface defect (9) that is a function of two parameters, h and r. If so, i.e., ΔS has the minimum at the defined variables $h=h_0$ and $r=r_0$, which are the solutions of the equations

$$\Delta S'_h = 0; \tag{10}$$

$$\Delta S'_r = 0, \tag{11}$$

then the needle-shaped surface of the particle (Fig. 3, c) will be the most stable among all the other possible shapes. Necessary conditions for the existence of the minimum are the inequalities (see, e.g. Refs. [39,40]):

$$\mathrm{Det} = \Delta S''_{hh}(h_0, r_0)\,\Delta S''_{rr}(h_0, r_0) - \Delta S''_{hr}(h_0, r_0)\,\Delta S''_{rh}(h_0, r_0) > 0; \tag{12}$$

$$\Delta S''_{hh}(h_0, r_0) > 0, \qquad \Delta S''_{rr}(h_0, r_0) > 0. \tag{13}$$

Eqs. (10) and (11) are reduced to, respectively,

$$\frac{1}{\varkappa}\ln\left(\sqrt{1+\varkappa^2}+\varkappa\right)=\frac{1}{3}\left\{2+\sqrt{1+\varkappa^2}-\frac{8}{3}\frac{1}{\varkappa^2}\left[\left(1+\varkappa^2\right)^{3/2}-1\right]\right\}; \tag{14}$$

$$\frac{1}{\varkappa}\ln\left(\sqrt{1+\varkappa^2}+\varkappa\right)=3\sqrt{1+\varkappa}-\frac{4}{3}\frac{1}{\varkappa^2}\left[\left(1+\varkappa^2\right)^{3/2}-1\right] \tag{15}$$

where the denotation

$$\varkappa = 2h/r \tag{16}$$

is introduced. Compatibility of Eqs. (14) and (15) is provided by equating their right-hand sides. It gives the following equation for $\varkappa$:

$$6\varkappa^2 + 5 = \left(\varkappa^2 - 5\right)\sqrt{1+\varkappa^2}. \tag{17}$$

The solution of Eq. (17) is

$$\varkappa_0 \simeq 0.8889025353. \tag{18}$$

One finds the second derivatives of ΔS:

$$\Delta S''_{hh} = \mathfrak{N}\pi\left\{16\frac{1}{\varkappa^4}\left[\left(1+\varkappa^2\right)^{3/2}-1\right]\right.$$
$$\left. +8\frac{1}{\varkappa^3}\ln\left(\sqrt{1+\varkappa^2}+\varkappa\right)-16\frac{2+\varkappa^2}{\varkappa^2}\sqrt{1+\varkappa^2}\right\}; \qquad (19)$$

$$\Delta S''_{rr} = \mathfrak{N}\pi\left\{8\frac{1}{\varkappa^2}\left[\left(1+\varkappa^2\right)^{3/2}-1\right]\right.$$
$$\left. +6\frac{1}{\varkappa}\ln\left(\sqrt{1+\varkappa^2}+\varkappa\right)-4\frac{3+2\varkappa^2}{\sqrt{1+\varkappa^2}}-2\right\}; \qquad (20)$$

$$\Delta S''_{hr} = \mathfrak{N}\pi\left\{-\frac{32}{3}\frac{1}{\varkappa^3}\left[\left(1+\varkappa^2\right)^{3/2}-1\right]\right.$$
$$\left. -6\frac{1}{\varkappa^2}\ln\left(\sqrt{1+\varkappa^2}+\varkappa\right)+2\frac{11+7\varkappa^2}{\varkappa\sqrt{1+\varkappa^2}}\right\}; \qquad (21)$$

$$\Delta S''_{rh} = \mathfrak{N}\pi\left\{-\frac{32}{3}\frac{1}{\varkappa^3}\left[\left(1+\varkappa^2\right)^{3/2}-1\right]\right.$$
$$\left. -6\frac{1}{\varkappa^2\ln}\left(\sqrt{1+\varkappa^2}+\varkappa\right)+2\frac{11+10\varkappa^2}{\varkappa\sqrt{1+\varkappa^2}}\right\}. \qquad (22)$$

By substituting the four derivatives (19)–(22) into inequalities (12) and (13) we obtain at $\varkappa = \varkappa_0$ (see (18)), respectively:

$$\left.\text{Det}\right|_{\varkappa_0} = (\mathfrak{N}\pi)^2\{2.645513 \times 3.835575 - (-0.531893) \times 4.518111\}$$
$$= (\mathfrak{N}\pi)^2 \times 12.550216 > 0; \qquad (23)$$

$$\Delta S''_{hh}(\varkappa_0) = \mathfrak{N}\pi \times 2.645513 > 0, \qquad \Delta S''_{rr}(\varkappa_0) = \mathfrak{N}\pi \times 3.835575 > 0. \qquad (24)$$

As is seen from expressions (23) and (24), the necessary conditions for the existence of the minimum of ΔS are satisfied. Thus the function $\Delta S(h,r)$ (9) really has the minimum at $h = h_0$, $r = r_0$. Substituting respective values of $\varkappa_0$ and h_0 from (18) and (16) into expression (9) we can rewrite expression (8) in the form

$$S = 4\pi R_{\text{part}}^2 + \mathfrak{N}\pi r_0^2 \times 2.4157446 \qquad (25)$$

where r_0 corresponds to the optimal radius of the needle base. As evident from expression (25), the variation of R_{part} leads to the respective variation of r_0.

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Let us derive the needle volume V_{needle}. It can easy be done in view of the rotation of the curve (4) around the OY axis:

$$V_{\text{needle}} = \pi \int_0^h x^2(y)\,dy = \pi \int_0^h \left\{ r(1 + \sqrt{y/h}\,) \right\}^2 dy$$

$$= \frac{11}{12}\pi r^2 h. \tag{26}$$

At point (h_0, r_0):

$$V_{\text{needle}}^{(0)}(h_0, r_0) = 0.81482729 \times \pi r_0^3. \tag{27}$$

Clearly, the total volume of needles should satisfy the inequality

$$\mathfrak{N} V_{\text{needle}}^{(0)} \ll \frac{4\pi}{3} R_{\text{part}}^3. \tag{28}$$

From here one obtains the restrictions to r_0:

$$r_0^3 \ll R_{\text{part}}^3 / \mathfrak{N}. \tag{29}$$

Inequality (29) with respect to the value r_0 is the distinctive adiabatic condition: the two states of surface polarization (Fig. 3 c) of the particle can be considered as practically stable only if r_0 is as small as the condition (29) requires.

It follows from (29) that the surface defect ΔS (25) that generates the electric charge in a particle is significantly smaller as compared with the ground surface $4\pi R_{\text{part}}^2$. The surface ΔS covers the volume $4\pi R_{\text{part}}^3/3$ responsible for gravitational properties of the particle. However, on the other hand, the effective curvature of the needle is considerably greater than that of the ground surface of the particle. That is why it is logical that the force on the side of needles with the typical dimension $h_0 \approx 0.45 r_0$ acts upon surrounding superparticles much strongly than that caused by the sphere with the radius R_{part}.

5. ELECTRIC CHARGE AND ITS MOTION

It is obvious that each nth 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 $\vec{u}\, h_0/\hbar$ can be interpreted as an elementary vector of the electric field, i.e.

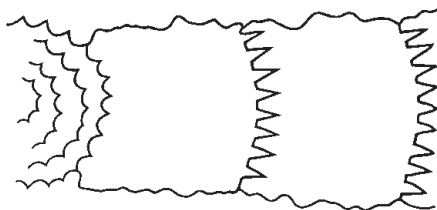$$\vec{\mathcal{E}}_{0n} = \vec{u}\, \frac{h_0}{\hbar} \tag{30}$$

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Figure 5: Superparticles polarized by the positive charged particle-"chestnut". The positive polarization induced in the superparticles is directed outside the superparticles (needles out); the negative polarization is directed inside the superparticles (needles in).

where the normalized section $\mathfrak{h}$ plays the role of a "quantum" of the length of the needle. The flux U_n of the vector $\vec{\mathcal{E}}_{0n}$ through the surface $\delta s_{n0} \equiv \pi r_0^2$ of the nth needle base may be written in the form of scalar product

$$U_n = \vec{\mathcal{E}}_{0n} \cdot \delta \vec{s}_{n0}. \tag{31}$$

Then the elementary electric charge $\tilde{e}$ can be determined as the total sum of all fluxes U_n through the particle surface:

$$\tilde{e} = \sum_{n=1}^{\mathfrak{N}} U_n = \mathfrak{N}\Big(\vec{\mathcal{E}}_{0n} \cdot \delta \vec{s}_{n0}\Big). \tag{32}$$

Note that a constancy of the charge $\tilde{e}$, for instance, for the lepton series, should be provided by increasing the radius r_0 when R_{part} decreases: $r_{0e} < r_{0\mu} < r_{0\tau}$ when $R_e > R_\mu > R_\tau$. On the background of the noise the stable polarization of the "chestnut" (i.e., a quantum of fractal deformations) in the state of rest induces the same polarization on surrounding superparticles, such that two adjacent superparticles exhibit opposite forms: one in the sense of convexity and the other in the sense of concavity (Fig. 5). The neighboring superparticles transmit the particle polarization to the adjacent superparticles up to the boundary of the crystallite whose size is defined by the Compton wavelength of the particle $\lambda_{\mathrm{C}} = h/Mc$ [21] and hence the field $\vec{\mathcal{E}}_{0n}$ shown in Fig. 5 extends for a distance of the radius λ_{C} from the particle.

Let us assume that the height of the needle can vary (for example, it can oscillate between magnitudes h_0 and $h_0 - \delta h_0$). In this case each of the needle

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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 $\vec{\mathcal{E}}_n$ can be associated with the scalar function $\Phi_n(h) \propto h$, i.e.

$$\vec{\mathcal{E}}_n(h) = -\nabla_h \Phi_n(h) \tag{33}$$

(so $\vec{\mathcal{E}}_n$ is a co-vector).

On the other hand, the spike of each nth needle is able to deviate from its equilibrium position, i.e., the bending of the needle from its axis of symmetry must not be ruled out. It is obvious that the value of 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 rather than to a vector that is true only for the displacement of a separate point. Let us designate this field as $\vec{\mathcal{A}}_n$.

Let us treat the motion of the "chestnut" along its spatial trajectory l. The interaction of a moving particle with superparticles results in a very specific dynamics of the particle along its path [19-23]. In those works we have studied features associated with the translation motion and the intrinsic motion (i.e., an asymmetric pulsation of the center-of-mass of a particle). There was no need to introduce the rotational degree of freedom in our previous papers. However, there is a good reason to do it now: It is precisely this motion of the charge that the rotational electric and magnetic fields generate.

The initial condition is the significant characteristic of the motion. In preceding papers [19-23], an initial spatial velocity $\vec{v}_0$ of the particle was regarded as a main property. The value of v_0 described both the translation movement and the intensity of the proper pulsation of the particle. Besides we assumed that the velocity v_0 was an essential characteristic of the motion of elements of the particle surface as well. Aside from the value of v_0, which has to pose a dynamics for all the three kinds of degrees of freedom of the particle, the intrinsic motion and the surface motion in addition should have some initial conditions. The direction of the displacement of the center-of-mass of the particle in relation to the vector $\vec{v}_0$ should ensure the condition for the intrinsic motion (spin), i.e., along or against $\vec{v}_0$. In the case of the surface motion, we may assume that the direction of the field $\mathcal{A}_n$ of each nth needle is transversal to the vector $\vec{v}_0$. Besides, the vector $\vec{\mathcal{A}}_n$ can be oriented either to the right or to the left relative to $\vec{v}_0$ (compare with the photon, a carrier of the electrodynamic field, which is characterized by the transversal polarization, either right or left in relation to its path).

Let us extend the major features of the dynamics of a chargeless particle [19-23] to the charged one. That is, one can suppose that with the motion of

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the "chestnut", respective magnitudes of the scalar and vector fields, Φ_n and $\vec{\mathcal{A}}_n$, for each nth needle oscillate with the period of collisions T in time and with the period λ in space (here $\lambda = v_0 T$). Thus with each ith collision of the particle with an ingoing superparticle, the former emits an inerton. With regard for the availability of the charge state on the superparticle surface, this inerton also carries over a bit of the electromagnetic field. [Recall that in solid state physics the mixture of two different quasi-particles in one entity is of frequent occurrence; in particular, composite quasi-particles can be attributed to the polariton (the mixture of light and polarized optical phonons), the polaritonic exciton (the mixture of the polariton and exciton), the excitonic polaron (the mixture of the polaron and exciton), etc.] The pattern of the motion of a charged particle shrouded in its inerton-photon cloud is schematically illustrated in Fig. 6. The particle emits inerton-photon quasi-particles that move from superparticle to superparticle by the relay mechanism. Within the period T_i of the collision between the particle and the ith emitted inerton-photon, a part of the velocity vector $\vec{v}_{0i}$ is transmitted from the particle to the quasi-particle and remains constant in the latter. However, phase states of the ith quasi-particle at the moments $t_i = T_i \aleph$ where $\aleph = 0, 1, 2, ...$ and $t_i = (2\aleph + 1)T_i/2$ are absolutely different [24] (here $\aleph$ designates the order number of the de Broglie section λ in a whole particle path l; this is because the length of the particle path l is subdivided into a set of sections λ). At the moment $t_i = 0$, the quasi-particle possesses the inert mass and the electric polarization and the motion of the center-of-mass and the surface polarization (i.e., the rotation of the electric field) begins from that. At the moment $t_i = T_i/2$, the distance between the particle and the quasi-particle is equal to Λ_i and the quasi-particle does not possess any mass in this point (the mass is transformed here to a local deformation of the tessellattice as a whole called the 'rugosity' in Ref. [24]). The deformation is anisotropic; in this position the quasi-particle's spin is found in the explicit form [21,24]. Moreover, the anisotropic state is specified by the axial polarization that can be considered as a bit of the magnetic field.

The same happens to the particle: at the moment $t = 0$, it is characterized by the initial velocity of translational motion v_0, by the inert mass $M_0/\sqrt{1 - v_0^2/c^2}$, by the normal polarization, or fractality of the surface (the electric charge), by the initial velocity v_0 of the intrinsic motion (the motion of center-of-mass) and by the initial velocity v_0 of the motion of the surface polarization. At the moment $t = T/2$, the particle is found at rest: its velocity of the translational motion is equal to zero, the mass equals 0 as well, the center-of-mass is displaced from the
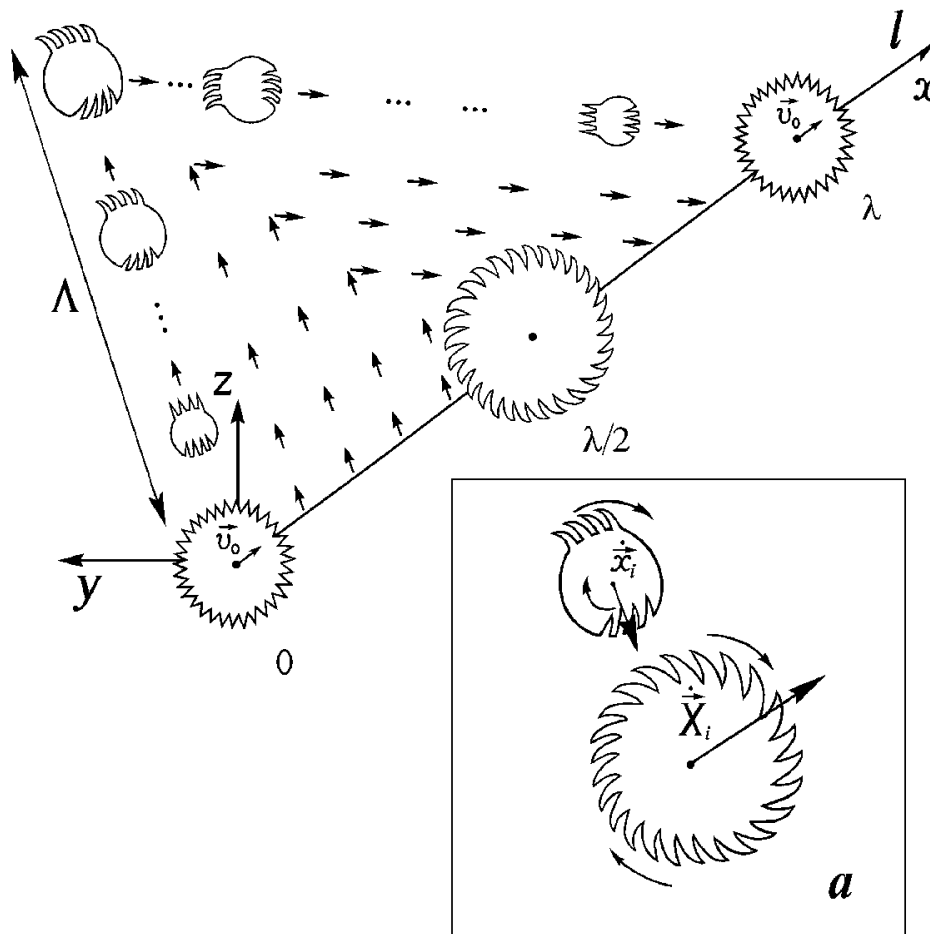
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Figure 6: Diagram of the motion of the positive charged particle. The particle is accompanied by electromagnetic polarized inertons, or inerton-photons, or simply photons (it is obvious that these particle's polarized inertons correspond to so-called "virtual photons" of quantum electrodynamics). (a) the moment of absorption of the ith inerton-photon by the particle.

equilibrium position (there is the spin) and the particle surface is specified by the axial polarization (i.e., one can see the explicit magnetic charge – the monopole, Fig. 6).

Let us analyze the motion of the scalar Φ_n and vector $\mathcal{A}_n$ fields mathematically. Dimensionality of these fields conforms to length. Therefore, the corresponding velocities are $\dot{\Phi}_n$ and $\dot{\mathcal{A}}_n$. For the sake of simplicity we will describe the inerton-photon cloud as a whole quasi-particle. Let ϕ_n and $\vec{\alpha}_n$ be the scalar and vector fields, respectively, of the nth effective needle of this quasi-particle; hence the velocities of the given fields are $\dot{\phi}_n$ and $\dot{\vec{\alpha}}_n$. 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:

$$
\begin{aligned}
\mathcal{L}_n &= C\Big\{\frac{1}{2}\dot{\Phi}_n^2 + \frac{1}{2}\dot{\vec{\mathcal{A}}}_n^2 + \frac{1}{2}\dot{\phi}_n^2 + \frac{1}{2}\dot{\vec{\alpha}}_n^2 \\
&\quad - v_0\Big(\dot{\Phi}_n\nabla\vec{\alpha}_n + \dot{\phi}_n\nabla\vec{\mathcal{A}}_n\Big) - v_0^2\Big(\nabla\times\vec{\mathcal{A}}_n\Big)\Big(\nabla\times\vec{\alpha}_n\Big) \Big\}
\end{aligned}
\tag{34}
$$

(C is a constant, its dimensionality in SI is kg/m^3). Here quadratic forms in the first line correspond to the kinetic energy of the fields Φ_n and $\vec{\mathcal{A}}_n$ of the nth particle's needle and the kinetic energy of the fields ϕ and $\vec{\alpha}_n$ of the nth effective needle of the cloud. The next to the last and the last terms describe the interaction between the fields of the particle and the cloud. In expression (34), the fields are differentiated by the time t that is set as the proper time of the particle, i.e., $t = l/v_0$ is a natural parameter, because l is the length of the particle path [20]. It is important to emphasize that owing to the introduction to the Lagrangian density (34) such operators as the divergence and the curl the derivatives $\dot{\Phi}_n$, $\dot{\phi}_n$ and $\dot{\vec{\mathcal{A}}}_n$, $\dot{\vec{\alpha}}_n$ should be treated as the partial derivatives: $\dot{\Phi}_n = \partial\Phi_n/\partial t$, $\dot{\phi}_n = \partial\phi_n/\partial t$ and $\dot{\vec{\mathcal{A}}}_n = \partial\vec{\mathcal{A}}_n/\partial t$, $\dot{\vec{\alpha}}_n = \partial\vec{\alpha}_n/\partial t$. This means that these time derivatives describe changes of the corresponding fields in those points $\vec{r}$ of the particle trajectory l in which divergences $\nabla\vec{A}_n$ and $\nabla\vec{\alpha}_n$ and vorticities $\nabla\times\vec{A}_n$ and $\nabla\times\vec{\alpha}_n$ are taken. The operator ∇ in expression (34) is constructed on the spatial coordinate $\vec{r}$ that is defined as $\vec{r} = \vec{\ell} + \overrightarrow{(R_{\mathrm{part}} + h)}$, where $\vec{\ell}$ is the radius vector of equilibrium position of the center-of-mass of the particle on the path l; $\overrightarrow{(R_{\mathrm{part}} + h)}$ is the vector eliminating from the equilibrium position of the center-of-mass of the particle to the spike of the nth needle ($\vec{\ell}$ and h change along the particle trajectory, but R_{part} is considered as a constant, though it is reduced along the trajectory owing to the so-called relativistic effect [20]. So $\vec{r}$ is the radius vector of the location of the spike of the nth needle. It is

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obvious that $\vec{r}$ describes the sharp location of the nth needle of the cloud.

We can put the following relations that describe the local electro-neutrality:

$$\Phi_n + \phi_n = 0, \qquad \vec{\mathcal{A}}_n + \vec{\alpha}_n = 0. \tag{35}$$

Then the Lagrangian density (34) may be presented as

$$\mathcal{L}_n = \mathcal{L}_n^{\text{part}} + \mathcal{L}_n^{\text{cloud}}; \tag{36}$$

$$\mathcal{L}_n^{\text{part}} = C\left\{\frac{1}{2}\dot{\Phi}_n^2 + \frac{1}{2}\dot{\vec{\mathcal{A}}}_n^2 + v_0\dot{\Phi}_n\nabla\vec{\mathcal{A}}_n + \frac{1}{2}v_0^2(\nabla\times\vec{\mathcal{A}}_n)^2\right\}; \tag{37}$$

$$\mathcal{L}_n^{\text{cloud}} = C\left\{\frac{1}{2}\dot{\phi}_n^2 + \frac{1}{2}\dot{\vec{\alpha}}_n^2 + v_0\dot{\phi}_n\nabla\vec{\alpha}_n + \frac{1}{2}v_0^2(\nabla\times\vec{\alpha}_n)^2\right\}. \tag{38}$$

Since the Lagrangian densities (37) and (38) have the same form, one can treat the behavior of the potentials of the particle's needle only. The Lagrangian density (37) is a function of $\dot{\Phi}_n$, $\nabla\Phi_n$ and $\dot{\vec{\mathcal{A}}}_n$, $\nabla\vec{\mathcal{A}}_n$. In this case, the Euler-Lagrange equations take the form (see, e.g. ter Haar [41]):

$$\frac{\partial}{\partial t}\frac{\partial\mathcal{L}}{\partial\dot{Q}} - \frac{\delta\mathcal{L}}{\delta Q} = 0 \tag{39}$$

where the functional derivative

$$\frac{\delta\mathcal{L}}{\delta Q} = \frac{\partial\mathcal{L}}{\partial Q} - \frac{\partial}{\partial x}\frac{\partial\mathcal{L}}{\partial(\frac{\partial Q}{\partial x})} - \frac{\partial}{\partial y}\frac{\partial\mathcal{L}}{\partial(\frac{\partial Q}{\partial y})} - \frac{\partial}{\partial z}\frac{\partial\mathcal{L}}{\partial(\frac{\partial Q}{\partial z})}. \tag{40}$$

For the Lagrangian density (37) Eq. (39) gives the following two equations:

$$\ddot{\Phi}_n + v_0\nabla\dot{\vec{\mathcal{A}}}_n = 0; \tag{41}$$

$$\ddot{\vec{\mathcal{A}}}_n + v_0\nabla\dot{\Phi}_n + v_0^2\nabla\times(\nabla\times\vec{\mathcal{A}}_n) = 0. \tag{42}$$

From Eq. (41) we obtain

$$\dot{\Phi}_n = -v_0\nabla\vec{\mathcal{A}}_n + \text{const.} \tag{43}$$

Substituting $\dot{\Phi}_n$ from Eq. (43) into Eq. (42) we get

$$\ddot{\vec{\mathcal{A}}}_n - v_0^2\nabla(\nabla\vec{\mathcal{A}}_n) + v_0^2\nabla\times(\nabla\times\vec{\mathcal{A}}_n) = 0. \tag{44}$$

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With the known formula

$$\nabla(\nabla\vec{b}) - \nabla \times (\nabla \times \vec{b}) = \nabla^2\vec{b} \tag{45}$$

we can write instead of Eq. (44)

$$\ddot{\vec{\mathcal{A}}}_n - v_0^2 \nabla^2 \vec{\mathcal{A}}_n = 0. \tag{46}$$

Integrating Eq. (42) over t we can solve the equation relative to the variable $\dot{\vec{\mathcal{A}}}_n$. By substituting the obtained expression for $\dot{\vec{\mathcal{A}}}_n$ into Eq. (41) we come to equation

$$\ddot{\Phi}_n - v_0^2 \nabla^2 \Phi_n - v_0^3 \left(\nabla \times \left(\nabla \times \int \vec{\mathcal{A}}_n \, dt \right) \right) = 0. \tag{47}$$

Since the formula

$$\nabla(\nabla \times \vec{b}) = 0 \tag{48}$$

is valid for any vector field $\vec{b}$, the last term in Eq. (47) equals zero and we arrive at equation

$$\ddot{\Phi}_n - v_0^2 \nabla^2 \Phi_n = 0. \tag{49}$$

The same equations can be derived for the fields $\vec{\alpha}_n$ and ϕ_n from the Lagrangian density (38).

The total fields of the particle and the cloud are respectively:

$$\Phi = \sum_{n=1}^{\mathfrak{N}} \Phi_n, \qquad \vec{\mathcal{A}} = \sum_{n=1}^{\mathfrak{N}} \vec{\mathcal{A}}_n; \tag{50}$$

$$\phi = \sum_{n=1}^{\mathfrak{N}} \phi_n, \qquad \vec{\alpha} = \sum_{n=1}^{\mathfrak{N}} \vec{\alpha}_n. \tag{51}$$

Evidently there is a phase lag between the fields Φ and $\vec{\mathcal{A}}$ (analogously for ϕ and $\vec{\alpha}$). The value of the lag is equal to $\pi/2$. As seen from the wave equations (46) and (47), the rate of change for each of the fields is defined by the velocity v_0 of the spatial motion of the particle. The initial conditions should be the following. For the scalar field: $\Phi(0) = \Phi_0$, i.e., at the moment $t = 0$, the charge state of the particle surface is entirely characterized by the central symmetry ($\mathfrak{N}$ elementary vectors stick out of the surface, $\vec{\mathcal{E}}_{0n} = -\nabla\Phi_n|_{h=h_0}$), at the moment $t = T/2$ (or the spatial half- period $\lambda/2$), the field Φ reaches the minimum, rather zero; then at the moment $t = T$ (or the spatial period λ), $\Phi(T) = \Phi_0$ again and so on. For

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the vector field: $\dot{\vec{\mathcal{A}}}(0) = \vec{\epsilon}_\pm v_0$ [recall that the dimensionality of the fields $\vec{\mathcal{A}}$ and $\vec{\alpha}$ is length] where $\vec{\epsilon}_\pm = \pm 1$ is the polarization vector; this condition implies that at the moment $t = 0$ all the $\mathfrak{N}$ needles on the sphere take the same tangential velocity (to the right for $\epsilon_+ = 1$ or to the left for $\epsilon_- = -1$ relative to the particle path l) and begin to move synchro. At the moment $t = T/2$, the tangential velocity of the needles decreases to zero, i.e., at this moment the deviation, or more exactly, the bending of the needles are maximal and the charge state of the particle surface is entirely characterized by the axial symmetry (Fig. 6). Then at $t = T$, one has $\dot{\vec{\mathcal{A}}}(T) = \vec{\epsilon}_\pm v_0$ and so on.

6. THE CHARGE IN ELECTROMAGNETIC FIELD

Let us examine a flux of free photons, elementary excitations of space, which carry over scalar and vector polarizations, i.e., the field potentials ϕ and $\vec{\alpha}$, from superparticle to superparticle by means of the relay mechanism. Clearly the motion of the potentials ϕ and $\vec{\alpha}$ of a free photon along its trajectory is described by Eqs. (49) and (46), respectively; besides, in this case the velocity v_0 should be replaced by the speed of light c. However, the frequency ν of the phase alteration of the potentials ϕ and α is given by a particle or particles, which irradiated these photons ($\nu = 1/2T$ where T is the period of collisions between the particle and its own inerton-photon cloud [19-21]). The Lagrangian density $\mathcal{L}^{\text{cloud}}$ of a free photon has the form of expression (38) in which the following substitutions should be made: $\phi_n \to \phi$, $\vec{\alpha}_n \to \vec{\alpha}$ and $v_0 \to c$. So

$$\mathcal{L}_{\text{photon}} = C\left\{\frac{1}{2}\,\dot{\phi}^2 + \frac{1}{2}\,\dot{\vec{\alpha}}^2 + c\dot{\phi}\nabla\vec{\alpha} + \frac{1}{2}\,c^2(\nabla \times \vec{\alpha})^2\right\} \qquad (52)$$

The elementary charge $\tilde{e}$ is organized by the flux of the gradient of the field Φ of the particle, see formulas (32) and (33), therefore, the charge $\tilde{e}$ can fully interact with external photons, i.e., with the potential ϕ. Then the term of the Lagrangian density, which has to describe the interaction, can be taken in the form

$$-C\tilde{e} \times \phi\,\frac{c^2}{\mathcal{W}} \qquad (53)$$

where the factor $c^2/\mathcal{W}$ is introduced to guarantee the dimensionality required, i.e., the energy density, of the term (recall that the dimensionality of the value $\tilde{e}$ is the area, m^2, see (32)). The dimensionality of the parameter $\mathcal{W}$ is the volume, m^3

and therefore it is an effective volume occupied by the charge $\tilde{e}$ at its interaction with external photons.

Let us determine the charge jointly with its deformation coat, or the space crystallite and consider the inerton-photon cloud as the whole object. In that event the object will be characterized by the constant velocity $\vec{v}_0$ in the space and then the flux $\tilde{e}\vec{v}_0$ should be treated as a current. The current as a vector is capable to interact with an external vector field $\vec{\alpha}$. So the density of the interaction Lagrangian should be supplemented with one more term,

$$C\,\tilde{e}\,\vec{v}_0 \cdot \vec{\alpha}\,\frac{c}{\mathcal{W}}. \tag{54}$$

Let us now pass on to values whose dimensionality is traditional in physics. In the System International: the charge e is measured in C (Coulomb); the scalar potential φ in kg·m^2/(C·s^2); the vector potential $\vec{A}$ in kg·m/(C·s); the electric constant ε_0 in C^2·s^2/(kg·m^3). Having passed to these standard physical values φ, $\vec{A}$ and e, we should introduce a dimensional parameter η, such that

$$\vec{A} = \eta\vec{\alpha}, \qquad \varphi = \eta c\phi. \tag{55}$$

Using parameters $\mathcal{W}$ and η introduced above, the electric charge e and its density can be presented as follows: $e = \tilde{e}\varepsilon_0 c\eta$ and $\rho = e/\mathcal{W}$ respectively. Besides, the constant C entering the Lagrangian density (34), (36)–(38) and (52)–(54) can be written as $C = \varepsilon_0\eta^2$. Then in standard symbols the Lagrangian density of the electromagnetic field that interacts with a charge particle takes the form

$$\mathcal{L} = \frac{\varepsilon_0}{2c^2}\,\dot{\varphi}^2 + \frac{\varepsilon_0}{2}\,\dot{\vec{A}}^2 + \varepsilon_0\dot{\varphi}\nabla\vec{A} + \frac{\varepsilon_0 c^2}{2}\left(\nabla \times \vec{A}\right)^2 - \rho\varphi + \rho\vec{v}_0\vec{A}. \tag{56}$$

Note that the standard Lagrangian of the electromagnetic field does not contain $\dot{\varphi}$, because they do not know in what way it can be introduced (see, e.g. ter Haar [42]).

Euler-Lagrange equations (39) based on the Lagrangian density (56) culminate in the following equations for the scalar φ and vector $\vec{A}$ potentials of the electromagnetic field

$$\ddot{\varphi} + c^2\nabla\dot{\vec{A}} + \varepsilon_0 c^2\rho = 0; \tag{57}$$

$$\ddot{\vec{A}} + \nabla\dot{\varphi} + c^2\nabla \times (\nabla \times \vec{A}) - \rho\vec{v}_0 = 0. \tag{58}$$

Eqs. (57) and (58) are reduced to the two well-known D'Alambert equations, Tamm [43], for φ and $\vec{A}$:

$$\nabla^2\varphi - \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2} = -\frac{\rho}{\varepsilon_0}; \tag{59}$$

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$$\nabla^2 \vec{A} - \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2} = -\frac{\rho \vec{v}_0}{\varepsilon_0 c^2}. \tag{60}$$

Eqs. (59) and (60) are the consequence of the Maxwell equations if the electric field $\vec{E}$ and the magnetic induction $\vec{B}$ are associated with the potentials φ and $\vec{A}$ by the formulas

$$\vec{E} = -\nabla\varphi - \frac{\partial \vec{A}}{\partial t}, \qquad \vec{B} = \nabla \times \vec{A}. \tag{61}$$

The Lagrangian of a free photon can be obtained from expression (56) if one drops the two last terms. The equations of motion of the photon are

$$\ddot{\varphi} + c^2 \nabla \dot{\vec{A}} = 0; \tag{62}$$

$$\ddot{\vec{A}} + \nabla\dot{\varphi} + c^2 \nabla \times (\nabla \times \vec{A}) = 0, \tag{63}$$

which are reduced to the two wave equations for the photon potentials

$$\nabla^2 \varphi - \frac{1}{c^2}\frac{\partial^2 \varphi}{\partial t^2} = 0; \tag{64}$$

$$\nabla^2 \vec{A} - \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2} = 0. \tag{65}$$

At the same time the migration of the photon "core", which occurs by the relay mechanism from cell to cell, obeys equation [35]

$$\frac{d}{dt}\vec{l} = \frac{\vec{l}}{l}c \tag{66}$$

where $\vec{l}$ is the radius vector of the photon location and the equation is held for the proper time $t > t_0$ where t_0 is the "inoculating" time, i.e. the photon lifetime in one cell. Thus equations (64), (65) and (66) completely describe the behavior of the photon.

Note that the model leads to the Lorentz calibration automatically, because the calibration immediately follows from Eq. (62):

$$\nabla \vec{A} = -\frac{1}{c^2}\frac{\partial \varphi}{\partial t}. \tag{67}$$

The Maxwell equations act in the area of classical physics, i.e., when wave properties of a charged particle can be neglected. Evidently, this statement is

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the direct consequence of the Lagrangian density written in the form (56), which takes into account the interaction of the external field with the whole {particle + deformation coat + inerton-photon cloud} complex. The complex moves as a classical object and its intrinsic dynamics does not appear beyond the cloud boundary. The cloud is restricted along the particle trajectory by the spatial period (i.e., de Broglie wavelength) λ and in transversal directions to the trajectory by the cloud amplitude $\Lambda \sim \lambda c/v_0$. Thus the two particle parameters λ and Λ limit the application of classical electrodynamics. Yet the wavelength $\lambda_{\mathrm{photon}}$ of external photons (a section of a photon path or, in other words, the spatial period of the phase change of the potentials φ and $\vec{A}$) [35] and the time period $T_{\mathrm{photon}} = \lambda_{\mathrm{photon}}/c$ should satisfy the inequalities

$$\lambda_{\mathrm{photon}} \gg \Lambda, \qquad T_{\mathrm{photon}} \gg T. \tag{68}$$

With the execution of inequalities (68) the charged particle may be described by the classical Lagrangian

$$L = -M_0 c^2 \sqrt{1 - v_0^2/c^2} - e\varphi + e v_0 \vec{A} \tag{69}$$

where the velocity $\vec{v}_0$ describes the motion of the whole particle complex that is formed around the particle in the space tessellattice when the particle is created.

If an incident photon flux is specified by a strong intensity (for instance an intensive laser pulse), then a number of photons will fall on the aforementioned particle complex. In this case one should take into account the strong interaction between $\mathcal{N}$ external photons and the particle's inerton-photon cloud. The theory of the anomalous photoelectric effect based on such interaction has been constructed in paper [33].

7. CONCLUDING REMARKS

The theory of the real physical space developed in works [28-30] has allowed the construction of the theory of the charge in the form of a peculiar quantum of fractal deformations, or a chestnut created from a superparticle that is the building block of the space. The total number of superparticles of the space tessellattice that spreads and forms all the universe defines the number of the charge needles estimated by the value of $\mathfrak{N} \sim 10^{168}$. The approach proposed has allowed the geometric interpretation of major notions of electrodynamics such as the electric field vector $\vec{E}$ and the vector potential $\vec{A}$ of the magnetic field.
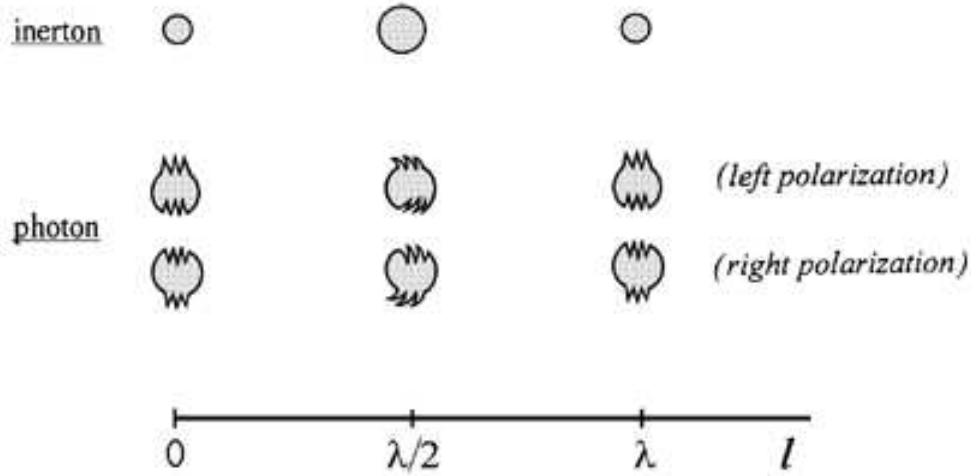
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Figure 7: Scheme of the motion of two basic quasi-particles of the space. (a) the motion of the free inerton; the volume of the inerton oscillates along its path l with the spatial period λ. (b) the motion of the free photon; the two possible transverse polarizations of the photon are shown. The polarization oscillates along the photon path l with the spatial period λ.

A particle and inerton-photon quasi-particles, which accompany it, carry the inert mass, electric charge and spin. Free, or real quasi-particles, irradiated by a particle should carry at least some of these properties as well. Namely, a free inerton that is radiated by a particle leaving its inerton cloud must carries the mass. A free photon should carry the electromagnetic polarization and, due to its location on the inerton, the photon should carry also the mass (see also Ref. [35]). These two quasi-particles move uniformly and rectilinearly already on a microscopic scale (Fig. 7), though at the submicroscopic consideration they travel by the relay mechanism hopping from superparticle to superparticle. The particle cannot move uniformly on a microscopic scale, its motion is adiabatic and nonstationary: Owing to the interaction with surrounding superparticles the particle moves with oscillating velocity [19-22]. However, on the macroscopic scale that prevails the size of the de Broglie wavelength λ the behavior of the particle resembles that of a classical object; and the behavior is exactly classical on a scale larger than the particle's inerton cloud amplitude Λ.

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The electric and magnetic polarizations are evolved separately, as Eqs. (49) and (46) demonstrate, and at the maximum distance from the particle, Λ, the electric polarization of the inerton-photon cloud (caused by the field φ) drops to zero, but the magnetic polarization reaches its maximum, $\vec{\alpha}_{\max}$. Since the mass of the inerton cloud gradually decreases to zero at the distance Λ from the particle by Newton's law $1/r$ [24], we may anticipate that the value of the electric polarization of the cloud should decrease by the same law $1/r$, i.e. Coulomb's law.

In Ref. [35] and in the present work we have argued that the photon polarization is kept on the surface of the corresponding inerton and, because of that, the photon is characterized by the mass as well. It must be emphasized once again that de Broglie [36,37] was the first who conjectured that the photon was characterizing by mass. Besides, the geometry of the charge constructed clearly demonstrates the availability of an additional mass introduced by the fractal deformations of the surface. Indeed the total volume of the particle should consists of two terms: the background volume $4\pi R_{\mathrm{part}}^3/3$ that corresponds to the particle mass and the volume of all the needles $\mathfrak{N}V_{\mathrm{needle}}^{(0)}$ (see expression (28)), though this correction seems should be neglected.

The present model of the electric charge leads to the Maxwell equations and hence the model perfectly agrees with classical electrodynamics. However, it is only true in the case when the frequency $\nu = E/h$ of proper oscillations of the particle along its path satisfies the inequality $\nu > \nu_{\mathrm{photon}}$ where ν_{photon} is the frequency of a photon of an applied electromagnetic field (note here $E = Mv_0^2/2$ where $M \equiv M_0/\sqrt{1 - v_0^2/c^2}$). With the opposite inequality, $\nu < \nu_{\mathrm{photon}}$, effects of strong interaction should take place, because the scattering of the photon by the inerton-photon cloud of the particle becomes inelastic, i.e., an outside photon penetrates into the cloud. The Compton scattering of light by the particle occurs at the boundary of the particle's space crystallite whose size is $\lambda_{\mathrm{C}} = Mc/h$ [19-25].

The screening of the particle charge is restricted by the crystallite and therefore the crystallite electric field must be extraordinary powerful. That is why the field should strongly polarize the crystallite creating virtual particle-antiparticle pairs. Such effects fall within the study of high energy physics. The theory of the real physical space and submicroscopic mechanics are capable to contribute a lot to high energy physics clarifying major notions of particle physics, hidden dynamics of particle interactions and inner reasons of particle transformations.

The concept of submicroscopic fractality starting on the scale of about 10^{-30}

m is distributed to cosmic scale subdividing the universe into ranges of intermediate levels (quarks, atoms, molecules, human size, star systems, etc.) [29,30]. Besides, it introduces charge topology in both the micro- and macroscopic world. For instance, typical manifestations of fractal geometry, a quantum of fractal deformations, on a macroscopic scale are a chestnut, flower, crown of a tree, hedgehog and so on (positive charges). Furthermore, if we determine the characteristic fractality of the root of plant and the male sex as a positive charge, we automatically should recognize that the opposite fractality, namely, the stomach of a living entity and the female sex is a typical negative charge.

It is interesting to emphasize that the submicroscopic fractality of space would be an actual ground for the justification of isomathematics that has been developing by Santilli [46] and his followers for the strongly interacting systems, from hadrons to molecules and molecular compounds (see, e.g. Ref. [47]).

Finally, let us turn to the epigraph to this paper, which was taken from the recent book *Vedic Physics* by Dr. Raja Ram Mohan Roy [48]. Roy analyzed the Vedic literature in detail reading it as a physicist and he was not acquainted with the author's study of the real space. His decoding of *The Ṛgveda*, which means 'the top of knowledge' in word-to-word translation to modern languages, shows that this is a book about the constitution of the real space, particle physics and cosmology. Indeed: i) the epigraph above (Roy's decoding) exactly corresponds to the contents of the present paper; ii) the three steps of God Viṣnu (the universe) represent the space web by Roy's decoding, which consists of indivisible cells, their interface (i.e., the surface) and the observer space (i.e., the aggregation of cells), which also in agreement with our theory. Besides, all other details uncovered by Roy are in accord with contemporary physics. Therefore it cannot be overestimated that the physics pattern presented in the study above, including Refs. [28-30], **exactly** matches the Vedic picture of the physical world, which has been unravelled in Roy's *Vedic Physics* [48].

APPENDIX

Let the shape of the surface needle be defined by the figure of rotation (Fig. 8) of the function

$$y = h \cdot \left(1 - \frac{x^2}{r^2}\right) \tag{A1}$$

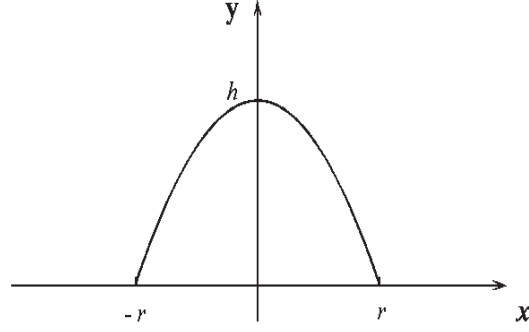round the OY axis. The area of surface of the needle is

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Figure 8: Graphic display of the function (A1).

$$\sigma_{\text{needle}} = 2\pi \int_0^h x(y)\, dl = 2\pi \int_0^h r\sqrt{1 - y/h}\ \sqrt{1 + \frac{r^2}{4h^2(1 - y/h)}}\ dy$$

$$= \frac{4\pi}{3}\, rh \cdot \left\{ \left[1 + \left(\frac{r^2}{2h}\right)^2\right]^{3/2} - \left(\frac{r}{2h}\right)^3 \right\}. \tag{A2}$$

In this case the surface defect is defined as

$$\Delta S(h, r) = \mathfrak{N} \cdot \left[\sigma_{\text{needle}}(h, r) - \pi r^2\right]. \tag{A3}$$

The derivatives necessary for the analysis of the needle stability are the following:

$$\Delta S_r'/\mathfrak{N} = \frac{2\pi}{3}\frac{r}{\varkappa}(1 + \varkappa^2)^{3/2} + 2\pi r \varkappa \sqrt{1 + \varkappa^2} - \frac{8\pi}{3} r \varkappa^2 - 2\pi r; \tag{A4}$$

$$\Delta S_h'/\mathfrak{N} = \frac{4\pi}{3} r\, (1 + \varkappa^2)^{3/2} - 4\pi r \varkappa^2 \sqrt{1 + \varkappa^2} + \frac{8\pi}{3} r \varkappa^3; \tag{A5}$$

$$\Delta S_{rr}''/\mathfrak{N} = 6\pi \varkappa \sqrt{1 + \varkappa^2} + 2\pi \frac{\varkappa^3}{\sqrt{1 + \varkappa^2}} - 8\pi \varkappa^2 - 2\pi; \tag{A6}$$

$$\Delta S_{hh}''/\mathfrak{N} = 8\pi \varkappa^3 \sqrt{1 + \varkappa^2} + 8\pi \varkappa^5 \sqrt{1 + \varkappa^2} - 18\pi \varkappa^4; \tag{A7}$$

$$\Delta S_{rh}''/\mathfrak{N} = \frac{4\pi}{3}(1 + \varkappa^2)^{3/2} - 8\pi \varkappa^2 \sqrt{1 + \varkappa^2} - 4\pi \frac{\varkappa^4}{\sqrt{1 + \varkappa^2}} + 8\pi \varkappa^3; \tag{A8}$$

$$\Delta S_{hr}''/\mathfrak{N} = \frac{4\pi}{3}(1 + \varkappa^2)^{3/2} - 8\pi \varkappa^2 \sqrt{1 + \varkappa^2} - 2\pi \varkappa^4 \sqrt{1 + \varkappa^2} \tag{A9}$$

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where $\varkappa = r/2h$. Equations $\Delta S'_h = 0$ and $\Delta S'_r = 0$ in the explicit form are

$$\frac{1}{3\varkappa}(1+\varkappa^2)^{3/2} = 1 + \frac{\varkappa^3}{3} - \varkappa\sqrt{1+\varkappa^2}; \qquad (A10)$$

$$\frac{1}{3\varkappa}(1+\varkappa^2)^{3/2} = \varkappa\sqrt{1+\varkappa^2} - \frac{2}{3}\varkappa^2. \qquad (A11)$$

Compatibility of Eqs. (A10) and (A11) gives the following equation for $\varkappa$:

$$\varkappa^3 - 2\sqrt{1+\varkappa^2} + 1 = 0. \qquad (A12)$$

The solution to Eq. (A12) is

$$\varkappa = \varkappa_0 \simeq 1.323311. \qquad (A13)$$

Substituting $\varkappa_0$ into expressions (A6)-(A9) we obtain

$$\Delta S''_{rr}(\varkappa_0)/2\pi\mathfrak{N} \simeq -1; \qquad (A14)$$

$$\Delta S''_{hh}(\varkappa_0)/2\pi\mathfrak{N} \simeq 10^{-6}; \qquad (A15)$$

$$\Delta S''_{rh}(\varkappa_0)/2\pi\mathfrak{N} \simeq 0.882208; \qquad (A16)$$

$$\Delta S''_{hr}(\varkappa_0)/2\pi\mathfrak{N} \simeq 3.1995296. \qquad (A17)$$

By substituting the values of (A14)-(A17) into inequalities (12) and (13) we get

$$\frac{\mathrm{Det}|_{\varkappa_0}}{2\pi\mathfrak{N}} = -2.82265 < 0; \quad \Delta S''_{hh}(\varkappa_0) > 0, \quad \Delta S''_{rr}(\varkappa_0) < 0. \qquad (A18)$$

Inequalities (A18) point out that the surface defect (A3) has no extreme. Therefore the considered shape of the surface needle (A1) is unstable and hence cannot form the charge state in a cell of the tessellattice.

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