Theory of Natural Oscillatory Systems and Advance in Nanoelectronics

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***Abstract*—Specific treatments of some quantum phenomena substantial for progress in nanotechnology and nanoelectronics are presented. De Broglie waves are interpreted as oscillations of the generalized coordinates of natural oscillatory systems with distributed parameters (NOSs). The spatio-temporal localization of the NOS wave packets and Heisenberg's uncertainty principle both are assumed to be results of the stochastic exchange with action quanta between different NOSs. The quantum kinematics (spatio-temporal evolution of NOS wave packets), quantum dynamics (interaction by means of random exchange with momentum-energy quanta between wave packets of different NOSs), and quantum statistics (probability laws for the stochastic exchange with action quanta between the wave packets in the Minkowski spacetime) are discussed. Both the action four-scalar and the momentum-energy four-vector, as the directional flow of action through 3D world, are assimilated with the geometry of NOS eigenmodes in the Minkowski spacetime. The conservation law for the action is supposed as a necessary condition for the energy-momentum conservation. The simplest examples of NOS wave packets are given. Some outcomes of application of this theory to solid-state phenomena are discussed.**

Keywords*—nanotechnology; action; momentum-energy; matter wave; distributed oscillatory system; second quantization

I. Introduction

Nanoelectronics is the use of nanotechnology in electronic components. It covers a wide set of devices and materials, with the dimensions that are so small that the quantum mechanical properties need to be considered extensively. Nanoelectronics is not quite the future, since recent silicon CMOS technology generations, such as the 22-nanometer node, are already within this criterion. However, the outlook for this science is much greater. Among the very promising electronic components there are one-dimensional nanotubes or nanowires (e.g. silicon nanowires and carbon nanotubes), hybrid molecular-semiconductor devices, or pure molecular electronic elements. Moreover, nanoelectronics is considered sometimes as a "disruptive" technology because the present candidates are too different from traditional transistors and microchips.

The progress in fundamental science is just such important for the nanotechnology as the development of its engineering base. The quantum mechanics (QM) and the quantum electrodynamics (QED) [1] are the principal theoretical bases for nanoelectronics. Despite striking achievements in the engineering applications of these disciplines, there is no consensus in theoretical understanding the quantum world behavior yet. Such opinion is confirmed by the existence of many interpretations of the quantum theory other than the so-called "Copenhagen interpretation." Problems of the "Copenhagen school" are expressed in the best way in the notorious "Schrödinger's cat" paradox and David Mermin's "Shut up and calculate" sentence.

E.g., the Wheeler-Feynman's (and, earlier, Hugo Tetrode's) idea of "advanced" electromagnetic interactions along with "retarded" ones [2, 3] was recently reanimated by Yakir Aharonov, "patriarch" of the contemporary quantum theory [4]. Reasonable alternatives to the "Copenhagen interpretation" of the quantum theory were proposed in [5 – 7]. Those are concepts of natural electromagnetic (EM) and electron-positron (EP) distributed oscillatory systems (NEMOS, NEPOS) respectively, as real physical bases for de Broglie matter waves. Moreover, NEMOS and NEPOS are also alternatives to the "physical vacuum" of QED [1]. The statistical method of the second quantization of NEMOS and NEPOS was described in [8, 9]. In [10], some additional problems of quantum kinematics and quantum dynamics of electron waves and wave packets in vacuum and matters are discussed.

A unified discipline named as "theory of natural oscillatory systems" (TNOS) is proposed [11] for generalization of the ideas and achievements in the hypothesis of quantized natural oscillatory systems (NOSs) with distributed parameters as an alternative to both the "particle-wave dualism" and the complex "probability wavefunctions" of the "Copenhagen school." The term "quantum" is not used in TNOS advisedly, because this is quantum theory "in essence." E.g., fermion NOSs cannot be described with "multiparticle approximation" in principle. Because of the complexity of the raised problem, mainly issues of the action and momentum-energy physical interpretation are considered below.

II. Preliminary Physical Issues

As it is known from the theory of oscillatory systems, all natural waves pass through some media having oscillatory properties (it means that their Euler-Lagrange equations have oscillating solutions, not only decaying). De Broglie waves in their Born's interpretation are an inconceivable exception, as there is no known material object for physical realization of these "probability" oscillations.

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Such theory causes serious logical and physical problems. Try giving, e.g., an answer to a simple question: "How an electron in the Copenhagen interpretation can create the pressure on the walls of an infinitely deep potential well, if the probability of one's stay at those walls is zero?"

The above is obvious for many researchers, over hundred various interpretations of QM and QED other than the "orthodox" Copenhagen interpretation do exist. As a radical, yet logical solution, let us assume that there are no "hard" particles in atomic world at all, only vibrations and waves. Electron is neither small sphere nor any other clot of charged substance. All observable effects produced by "electrons" or "positrons" are results of NEPOS oscillations. Coordinates and velocities of the wave packets ("particles") have no strict sense, the occupation numbers for NEPOS eigenmodes should be considered instead. Thus, there is no principal difference between quanta of NEMOS ("photons") and "electrons."

Three facts are known from numerous experiments:

1. Momentum-energy four-vector is uniquely associated with the wave four-vector of some harmonic process in spacetime.

2. Rigorous conservation of momentum-energy occurs in each act of substance interaction.

3. There are no pure harmonic processes in nature. As it can be seen, these facts are mutually exclusive.

For solving this contradiction, let us assume that each non-harmonic process in nature is, in fact, a statistical ensemble of a quantity of harmonic processes. Such ensemble cannot be realized as a simple superposition of excited eigenmodes of a single NOS, because of the mutual orthogonality of the eigenmodes. A permanent nonlinear exchange with random action quanta between, at least, two different NOSs must take a place. Note that just the action is supposed as a fundamental "unit of operation" in the 4D spacetime, not momentum-energy, as in our 3D world.

The term "permanent" is used as an equivalent of "continuous" or "unceasing" to underscore that respective process cannot be considered as "passing through time." This random process, probably, takes a place "over" the spacetime, stochastically changing the state of all 4D Universe (like the "many-worlds interpretation" of QM). From the point of view of a 3D observer moving in time, all NOS eigenmodes, replacing one another, exist "at the same time," but with different probabilities.

The laws of the rigorous conservation of action and momentum-energy assume that momenta-energies of interacting NOS modes are strictly defined. Hence, those modes are pure eigenmodes of the NOSs. If so, the spatio-temporal coordinates of the exchanges with action quanta between NOSs are indefinable, the interaction between NOS eigenmodes occurs in the whole 4D Universe. The action and the momentum-energy of excited NOS eigenmodes are also absolutely nonlocalized, but the eigenmode interference creates localized spatio-temporal areas, where the eigenmode ensembles (wave packets) can interact with one another; those are spatio-temporal equivalents of the spectral representation. Also, there are no "pure" free oscillations of NOSs; all wave packets are stochastic combinations of their forced oscillations. So, the statistic (probabilistic) nature of QM and QED is caused by a permanent stochastic exchange with action quanta between different NOSs, not by Heisenberg's "uncertainty principle" or "zero-point oscillations of vacuum."

Thus, the principal physical objects in the 4D Universe are excited or unexcited eigenmodes of various NOSs. The principal physical process in the 4D spacetime is the stochastic exchange with action quanta between eigenmodes of different NOSs. Under some conditions, these action quanta progressively transfer momentum-energy from one wave packet to another. Time evolution of NOS spatially localized wave packets (e.g., their mutual "attraction" or "repulsion") during the motion of our 3D world through 4D spacetime is only some stable trend in such quantum chaos. In the same way, a statistical domination of gas molecules moving backward the gradient of their concentration is considered macroscopically as gas flow from areas with higher pressure. Only the spatio-temporally localized NOS wave packets make possible the interaction between different NOSs, not "pure" NOS eigenmodes.

The dispersion of NEPOS wave packets does not matter, because those packets, regardless of their spatial extensions, always arise or disappear as some single wholes. This is a natural result of the spatio-temporal nonlocality of the interaction between NOS eigenmodes. Note that "photon" emitted from an atom may also spread over a wide wave front in fundamentally non-dispersive NEMOS. Nevertheless, all momentum-energy of this "photon" immediately transfers to another atom, if the interaction with that atom occurs. I.e., the notorious "quantum jump" is, in fact, the specificity of the interaction between different NOSs in whole Minkowski spacetime.

III. Notations and Abbreviations

The 4D pseudo Euclidean formalism with imaginary time ("3+*i*") is assumed on default in this paper for the spacetime geometry. The Cartesian coordinate system is used; *x*, *y*, and *z* are the real-valued spatial coordinates; *t* is the temporal coordinate with dimension of imaginary length, which is defined as product of the "conventional" time, the modulus of the light velocity *c* in vacuum, and the imaginary unit.

Four-vectors in the Minkowski spacetime are mixed-valued with real spatial components and imaginary temporal one. Such "physical" four-vectors are marked with arrows (e.g. $\vec{a}$). The braces mean the combining scalar values into vectors $\vec{a} = \left\{a_x, a_y, a_z, a_t\right\}$. The scalar product of four-vectors $\vec{a}$ and $\vec{b} = \left\{b_x, b_y, b_z, b_t\right\}$ is of $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z + a_t b_t$, and squared four-vector $\vec{a}$ is of $(\vec{a})^2 = a_x^2 + a_y^2 + a_z^2 + a_t^2$. Four-matrices and four-tensors are enclosed in square brackets:

$$[c] \equiv \begin{bmatrix} c_{xx} & c_{xy} & c_{xz} & c_{xt} \\ c_{yx} & c_{yy} & c_{yz} & c_{yt} \\ c_{zx} & c_{zy} & c_{zz} & c_{zt} \\ c_{tx} & c_{ty} & c_{tz} & c_{tt} \end{bmatrix}.$$

Their mixed spatio-temporal components (e.g., c_{xt}) are imaginary, other terms are real-valued. Further, four-gradient $\vec{\nabla} = \{\partial/\partial x, \partial/\partial y, \partial/\partial z, \partial/\partial t\}$, four-divergence $\vec{\nabla}\cdot\vec{a} = = \partial a_x/\partial x + \partial a_y/\partial y + \partial a_z/\partial z + \partial a_t/\partial t$, and D'Alembert $\nabla^2 = \partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2 + \partial^2/\partial t^2$ operators are used to complete the 4D pseudo Euclidean mathematical tool.

Generic symbols may be substituted instead of the spatio-temporal coordinates and some indexes. τ is a generic symbol for *x*, *y*, *z*, or *t*. ξ is a generic symbol for *x*, *y*, or *z*. If one of the generic symbols τ or ξ appears in the summation sign (Σ), it means summation over all respective coordinates.

IV. Theoretical Part

Let us assume that quantization of total action of each NOS with interval of the Planck's constant η is a general principle of nature. It is supposed (by following Maupertuis) that just action, not momentum-energy, is a fundamental physical value for the 4D Universe. This value is discrete with the quanta of η. The discontinuity of action is the reason for the quantization of nature. Something that does not depend on the coordinate frame (relativistic scalar) is, evidently, more objective than values changing subject to the "point of view."

In the classic EM theory [12], the action H of a closed physical system "charged particle in its EM potential" is a sum of two components expressed in different forms:

1. Term for "charged particle" is an integral along the "particle trajectory" in the Minkowski four-space from event 1 $\vec{r}_1 = \{x_1, y_1, z_1, t_1\}$ to event 2 $\vec{r}_2 = \{x_2, y_2, z_2, t_2\}$.

2. Term for EM potential is the Lagrange function three-density (or, the same, the action four-density) $h(x, y, z, t)$ integrated over some four-volume in the Minkowski space.

In TNOS, only second term is considered as strict item. The real-valued action of total Universe is assumed as consisting of mutually dependent (by means of stochastic exchange with action quanta of $\pm\eta$) actions of all NOSs. The action of each NOS is produced by squared variations in spacetime of specific four-vector wavefunction $\vec{\aleph}(x, y, z, t)$ (for fermion NOSs, also by squared value of this wavefunction itself):

$$H = -i\int_V \vec{\aleph}\cdot\Lambda\vec{\aleph}\, dxdydzdt, \qquad \text{(IV.1)}$$

where Λ is so-called Euler-Lagrange operator, describing dynamics of the NOS by substitution in the Euler-Lagrange equation $\Lambda = 0$; V is the Universe total imaginary four-volume. Four-tensor (gravitational) and scalar (Higgs) wavefunctions also may be introduced to TNOS.

Relativistic scalars of action four-densities $h(x, y, z, t)$ for NEMOS and NEPOS can be coupled with the local deviations of these NOSs and their first-order derivatives as respectively

$$h^\gamma = i\left[(\vec{\nabla}\aleph_x^\gamma)^2 + (\vec{\nabla}\aleph_y^\gamma)^2 + (\vec{\nabla}\aleph_z^\gamma)^2 + (\vec{\nabla}\aleph_t^\gamma)^2\right]; \qquad \text{(IV.2)}$$

$$h^e = i\left[(\vec{\nabla}\aleph_x^e)^2 + (\vec{\nabla}\aleph_y^e)^2 + (\vec{\nabla}\aleph_z^e)^2 + (\vec{\nabla}\aleph_t^e)^2 + + k_e^2(\vec{\aleph}^e)^2\right] \qquad \text{(IV.3)}$$

(k_e is the NEPOS cutoff wavenumber). The total actions of NOSs (also relativistic invariants) are

$$H^\gamma = \int_V h^\gamma dxdydzdt; \qquad H^e = \int_V h^e dxdydzdt. \qquad \text{(IV.4)}$$

The Euler-Lagrange operators are calculated as

$$\Lambda\vec{\aleph} = \sum_\tau \frac{d}{d\tau}\left[\frac{\partial h}{\partial(\partial\vec{\aleph}/\partial\tau)}\right] - \frac{\partial h}{\partial\vec{\aleph}}, \qquad \text{(IV.5)}$$

so, the wave equation $\nabla^2\vec{\aleph}^\gamma = 0$ for $\vec{\aleph}^\gamma$ and the Klein-Gordon equation $\nabla^2\vec{\aleph}^e + k_e^2\vec{\aleph}^e = 0$ for $\vec{\aleph}^e$ are finally obtained.

The action of a NOS can be treated as consisting of a series of independent actions of the NOS eigenmodes $\vec{\aleph}_m(x, y, z, t)$ (the mutually orthogonal in the four-volume *V* items of the Fourier decomposition of $\vec{\aleph}$; *m* is the eigenmode number):

$$H_m = -i\int_V \vec{\aleph}_m\cdot\Lambda\vec{\aleph}_m\, dxdydzdt.$$

The quantization rules for a NOS and its *m*-th eigenmode are

$$H = L\eta; \qquad H_m = L_m\eta, \qquad \text{(IV.6)}$$

where $L = 0, \pm1, \pm2, \dots$ and $L_m = 0, \pm1, \pm2, \dots$ are so-called enforce numbers indicating how many positive or negative quanta of action keep the whole NOS and each eigenmode away from the pure free oscillation (with $H = 0$).

By the separation of variables, components of $\vec{\aleph}$ and $\vec{\aleph}_m$ can be written as products of four variables depending only on single of spatio-temporal coordinates. According to (IV.2), (IV.3), the action of each eigenmode in arbitrary coordinate frame can be considered as consisting of four mutually independent "anisotropic" items produced by variations of $\vec{\aleph}_m$ along the spatio-temporal coordinates and additional fifth "isotropic" item produced by deviation of $\vec{\aleph}_m$ from zero in the case of fermion NOS. E.g., if there is only one full variation of a NOS eigenfunction over total Universe along only one of the spatio-temporal coordinates, such eigenmode may have action of $\pm\eta$. The sign of this action quantum depends on which component of the NOS wavefunction (spatial or temporal) varies and what is the direction of the variation (time or space). The eigenmode's action may be zero, if the numbers of variations of some component in temporal and spatial directions are equal; or if the NOS is fermion and the action of the isotropic item "neutralizes" the action of NOS "rippling."

What is the "mechanical" momentum-energy four-vector $\vec{W} = \{W_x, W_y, W_z, W_t\}$ in TNOS, if the action is considered as more principal physical value? The momentum and the energy are 3D dynamic values defined as flow of action through our 3D world, uniformly moving in the temporal direction of Minkowski spacetime. "Rippled" in the spacetime excited NOS eigenmodes vibrate like animated cartoon from the point of view of a moving coordinate frame. The frequencies of these vibrations describe the eigenmodes' energies, while the speeds and directions of spatial displacements of the NOS oscillations' phases define the eigenmodes' "mechanical" momenta. A certain number of excited NOS eigenmodes always exists in the 4D Universe causing non-zero and invariable in any inertial frame system total energy of our 3D world together with some total momentum (also invariable in any inertial frame system). The total energy and momentum depend on the viewer's coordinate frame orientation.

Because the action of a NOS eigenmode consists of four directly independent anisotropic items, each of these items taken separately is quantized. As an outcome, quantization of momenta-energies of NOS eigenmodes has a place in our 3D world. It is easy to see that the "classic" formula of QED for the total momentum-energy four-vector of *m*-th eigenmode

$$\vec{W}_m = \eta K_m \vec{k}_m \, , \tag{IV.7}$$

where $\vec{k}_m$ is the wave four-vector (wavenumber) of this eigenmode; $K_m = 0, 1, \ldots$ is the eigenmode occupation number [1], is not so universal. Namely, (IV.7) does not consider the existence of both positive and negative action quanta as well as the same sign of energy for "particles" (with $k_{mt} > 0$) and "antiparticles" (with $k_{mt} < 0$). Therefore, it would be better to evaluate the total momentum-energy of individual eigenmodes and of a while NOS by means of integrating the respective components of the four-tensor of energy-stress density $[w]$ over all 3D volume of Universe. Unlike the classic EM theory [12], all components of $[w]$ (including diagonal ones) are defined in TNOS in simple and uniform manner:

$$w_{\tau\tau'} = \frac{\partial \vec{\aleph}}{\partial \tau} \cdot \frac{\partial \vec{\aleph}}{\partial \tau'} \, .$$

Alternatively, the total momentum-energy four-vector of *m*-th eigenmode may be calculated using a more complicated analogue of (IV.7), where signs of the eigenmode's action and the wave four-vector temporal direction are considered:

$$\vec{W}_m = \operatorname{sgn}(H_m) \operatorname{sgn}(k_{mt}) \eta K_m \vec{k}_m \, . \tag{IV.8}$$

Note that only spatio-temporal gradient of NOS deviation produces the momentum-energy, not the value of the deviation itself. So, the isotropic term in the expression for action of fermion NOSs (IV.3) is a "hidden" property of these NOSs, which does not participate in the interactions with other NOSs and does not create the momentum-energy. However, the action of the isotropic term can be converted to the action of the total momenta of resulting "photons" while the annihilation of fermion pairs (or vice versa during the pair creation). The existence of the isotropic summand in the expression for the action of the fermion NOSs (IV.3) means that each of these NOSs have a certain internal subsystem, which can also accumulate some action. This four-scalar sub-NOS, creating the "rest mass" for all fermion NOSs, may be associated with the hypothetical Higgs boson.

Because TNOS assimilates action, momentum, and energy, as physical values, with the pseudo Euclidean geometry in Minkowski spacetime and "velocity" of "time flow," the momentum-energy and angular four-momentum conservation laws in any inertial frame system become only results of trigonometric relations, so, cannot be void in principle (even during Heisenberg's "uncertainty interval"). However, two additional hypotheses are needed: conservation of the action and regularity of the "time flow." The latter is ensured by using an inertial coordinate frame (which assumes the four-velocity constancy). Let us consider the former requirement.

For creation of each "fold" (wave period) on a NOS, action quantum of $\pm\eta$ is needed. So, these "folds" cannot "appear from none" and "vanish to nothing." Therefore, some conservation law for the action must exist, indeed.

Despite any physical processes, the total sum of positive and negative action over all 4D Universe is some constant. Let us suppose this sum to be zero. This means that the real-valued and the imaginary-valued components of NOS wavefunctions and their respective derivatives totally provide for just equal numbers of the positive and the negative action quanta, respectively. Because the total action of the Universe is, apparently, identically equal to zero, the "least action principle" should be replaced with the "zero action principle."

One more assumption is that pure free oscillations (with $H = 0$) of different NOSs cannot interact with one another. So, an additional mechanism is needed to provide EM, gravitational and other interactions, generating the quantum dynamics of the Universe. Considering the fundamentally statistical manifestation of the known quantum effects, let us suppose this mechanism to be like the probabilistic thermodynamic phenomena.

Even though the free oscillations of NOSs are the most "steady," some number $L = 1, 2, \ldots$ of pairs of positive and negative action quanta always keeps two different interacting NOSs away from their natural vibrations, turning two eigenmodes of the both NOSs in forced ones. This number (so-called NOS enforce number) permanently stochastically changes, yet complying with typical thermodynamic regularity "greater L absolute value, less probability of such state." On the other hand, considering enormous number of different forced NOS eigenmodes in the Universe (consequently, the vanishingly small probability of just $L=0$ state), it can be postulated that all vibrations of NOSs are forced, not free. Just the forced oscillations of NOSs organize de Broglie wave packets being analogues of "virtual particles" of the traditional QM, while "real particles," as some non-interacting objects, do not exist in nature at all.

Let us consider a simple example. A 2D (x, t) space with dimensions of Ξ, T, respectively, is shown in Fig. 1. Our 3D world can be treated as section of $t = \mathrm{const}$, which uniformly shifts along t axis with the unit velocity $dt/dt = 1$ (see the bold arrows). What occurs in this section while it traverses the NOSs is what we observe from our 3D point of view. A stationary fully nonlocalized wave packet of NEPOS, consisting of single eigenmode with $k_t = 40\pi/\mathrm{T}$, is shown in Fig. 1, b. The wavefunction components for this packet are: $\aleph_x^e = \cos k_t t$; $\aleph_t^e \equiv 0$. Black color designates the maximal value of $\aleph_x^e$ component, while white color indicates the one's minimal value. The linear polarization of the wavefunctions cannot be realized in fermion NOSs, so, another component must be necessarily excited in quadrature to $\aleph_x^e$, e.g., $\aleph_y^e = \sin k_t t$. However, its behavior is the same as for $\aleph_x^e$. This wave packet contains 20 positive and 20 negative action quanta. The negative quanta are generated by variation of $\aleph_x^e$ in t direction, the positive ones are produced by the isotropic term in the expression for fermion NOS action (IV.3). Such eigenmode is a free oscillation of NEPOS. Because of imaginary essence of time, both $\aleph_x^e$ and $\aleph_y^e$ components create equal one-sided (analytic) squared spectra of h and H with a single harmonic at $k_t = 40\pi/\mathrm{T}$. Unexcited NEMOS, having no action quantum, is shown in Fig. 1, b in gray color with the wavefunction $\vec{\aleph}^\gamma \equiv 0$.

Now, let the interaction occurs between the temporal components of $\vec{\aleph}^e$ and $\vec{\aleph}^\gamma$. A pair of positive and negative action quanta is generated by the described above stochastic mechanism, and $\aleph_x^e$ component takes one variation along x axis (see Fig. 1, c) as well as one more positive action quantum. The temporal component of NEMOS wavefunction also obtains one variation along x (as in Fig. 1, d) and one negative action quantum. So, the new eigenmode of NEPOS contains 21 positive and 20 negative action quanta and is the forced oscillation. The excited NEMOS eigenmode contains one negative quantum and is also forced.

The NEPOS spectrum is enriched with two new harmonics at $k_x = \pm 2\pi/\Xi$. Just the same harmonics appear in NEMOS spectrum. The actions of both NOSs change by $\pm\eta$, as it was described, but their "mechanical" momenta remain zero, because the new (forced) oscillations both have spectra symmetric about zero in x direction (like "standing wave").

The NEMOS deviation in Fig. 1, d is positive at $x = 0$, because the "positron" eigenmode in Figs. 1 a, c has $k_t > 0$. The "electron" eigenmode with $k_t = -40\pi/\mathrm{T}$ after the similar interaction with NEMOS is shown in Fig 1, e. Note that the "electron" wavefunction visually does not differ from the "positron" one, but the excited NEMOS eigenmode is negative at $x = 0$ (see Fig. 1, f). The interaction process between NEPOS and NEMOS is possible due to the nonorthogonality of the resulting eigenmodes; both have temporal components $\aleph_t^e$ and $\aleph_t^\gamma$ respectively changing in x direction as $\cos(\pm 2\pi x/\Xi)$. Despite the absence of the "mechanical" momentum of NEMOS eigenmodes excited by the "rest electron," they have non-zero action and can create an "EM momentum" of another "electron" in addition to its "mechanical" one [13].

The wavenumbers of NEMOS harmonics always may be treated as the differences between wavenumbers of NEPOS

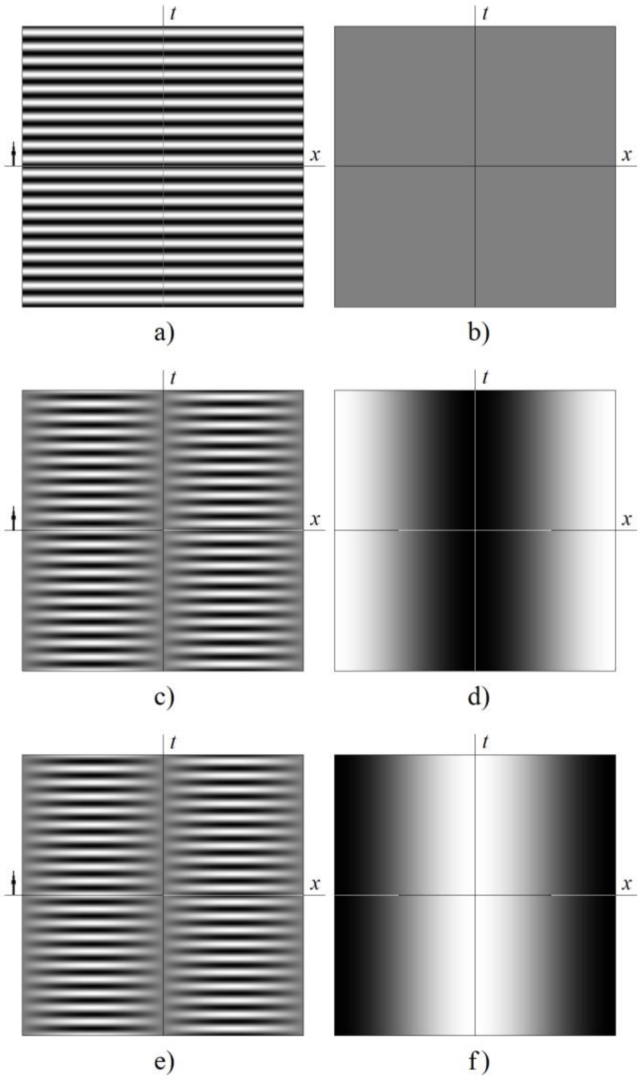

Fig. 1. 2D (x-t) sections of finite 4D Universe considered as some four-parallelepiped in pseudo-Euclidean space filled with NOS eigenmodes and wave packets.

wave packet harmonics. But the NEMOS wave packet "associated" with an "electron" has another envelope of its squared spectrum than the "original" NEPOS wave packet has, because NEPOS is the fermion NOS, while NEMOS is the boson one; so, the latter can have $K_m > 1$, while the former cannot. As a result, NEPOS has a "flat" squared spectrum about $k = 0$, while the NEMOS spectrum behaves as $1/k$ here, according to the Bose-Einstein statistics. This difference in the spectra causes essentially differing behavior of fermion and boson wavefunctions at far distances r from their maxima. NEMOS wavefunction $\vec{\aleph}^{\gamma}$ relaxes as $1/r$, while $\vec{\aleph}^{e}$ does it faster. This is the reason why bosons are considered rather as "fields," while fermions are done rather as "particles."

V. TNOS and Applied Science

The consistent application of the described theory may sometimes result in unexpected outcomes. E.g., static EM potential around a rest "electron" does not contain energy; all electron self-energy must be a result of NEPOS oscillation. Another outcome is that the action dH of a "free rest electron" at a time interval dt is zero, not of $-m_e dt$, as in the classic theory [12], where m_e is the "electron rest mass," because the action of a NOS free oscillation is identically equal to zero. One more outcome is the absence of "zero-point oscillations" of vacuum [9], because the respective value of eigenmode's "zero-point energy" $\eta\vec{k}_m/2$ does not satisfy the momentum-energy quantization principle. Only the zero-point oscillations of "composite" oscillators (like crystal lattices) exist, based on the interaction between NEPOS and NEMOS.

One of corroborations of our hypothesis is the existence of electron waves in conductors and superconductors. Solid-state theory considers unbounded (conductivity) "electrons" in metal crystals as normal modes of "electron gas" rather than localized particles squeezing one's way through atomic lattice. Why "electrons" in conductive media and "electrons" in vacuum exhibit different behavior? The reason is that all internal volume of the conductive or superconductive crystal is equipotential. High mobility of "electron gas" allows one effective smoothing any inhomogeneities in EM potential. Therefore, there are no harmonics of $\vec{\aleph}^{\gamma}$ differing from zero within a metal volume. If so, the described above mechanism of electron wave packet localization does not work for the "conductivity electrons." Only separate NEPOS eigenmodes can exist in the conductive media, except for the bounded (valence band) "electrons," which are essentially localized with strongly non-uniform EM potential of atomic nuclei.

The action conservation law is the reason also for the "direct interparticle action" [2, 3]. "Almost free photons," with both $\left|k_x^2 + k_y^2 + k_z^2\right| \approx \left|k_t^2\right|$ and $\left|k_x^2 + k_y^2 + k_z^2 + k_t^2\right| \ll \left|k_t^2\right|$, cannot accumulate the action from radiating atom, only can transfer it between "outside" oscillatory systems (e.g., from the initially excited atom to the unexcited one).

VI. Conclusion

Theory of natural oscillatory systems is a "bridge" between the classic theory of oscillatory media and the "Copenhagen interpretation" of the quantum theory. TNOS rationally explains known physical phenomena; but it does not use shady concepts of "probability waves" and "wave-particle dualism." Spatially or spatio-temporally localized wave packets of NOSs may be considered as full-value equivalents of "elementary particles." Instead, a new "overspacetime" statistical process of action quanta exchange between different NOSs is introduced. So, the wave packets are composite dynamic objects; their existence is possible due to the permanent stochastic interaction between different NOSs widening spectra of their oscillations and causing all those to be forced, not free. The proposed concept explains specific behavior of matter waves in vacuum, conductors, semiconductors, and superconductors. The results may be useful for the further development of new nanoelectronic components, quantum computers, as well as in various branches of nanotechnology.

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