Conjugate Parameters of Physical Processes and Physical Time

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Abstract

All physical phenomena run in nature with the continuous transformation of the kinetic field into the potential field, and *vise versa*, *i.e.*, they have the wave character. For this reason, the structure of expressions representing these fields (both real physical space and physical time space) must be potential-kinetic. Contemporary physics satisfactory describes the kinetic field, but the complete description of the potential subfield is absent. In this paper we partially fill in this gap, beginning from the description of harmonic oscillations (of a material point) and the physical time wave field-space.
Key words: potential-kinetic fields, oscillations, waves, physical time

Résumé

Tout phénomène physique se produit dans la nature par une transformation continuelle du champ cinétique en un champ de potentiel et vice versa, i.e., ils ont la caractéristique ondulatoire. Pour cette raison, la structure d'expressions, représentant ces champs (a la fois, espace physique réels et espace- temps physique) doit être aussi potentiel-cinétique. La physique contemporaine décrit de façon satisfaisante les champs cinétiques, mais la description complète du sous-champ potentiel est absente. Dans cet écrit, nous comblerons cette lacune partielle, en commençant par la description des oscillations harmoniques d'un point matériel et l'onde espace-champ du temps physique.

1. Introduction

1.1. Overview

The subjection of the basic parameters of physical systems to general principles of philosophy and logic evidences their completeness. However, not many know that. We have analyzed the physical parameters used for the description of harmonic oscillations and found their incompleteness with respect to the aforementioned subjection. Let us elucidate this statement.

Since the wave exchange of matter-space and rest-motion (*matter-space-time* for brevity) is in the nature of all phenomena, the *possibility* of rest and motion generates, at the definite conditions, potential-kinetic fields of *reality*, where *rest* (*potential field*) and *motion* (*kinetic field*) are inseparable linked in one potential-kinetic field [1]. The logical triad *matter-space-time* expresses an indissoluble bond of matter, space, and time. The logical pair *motion-rest* presents an indissoluble bond of motion and rest, *etc*.

The *possibility* of potential-kinetic processes must be estimated by the corresponding *probability* of rest-motion. Then, obviously, states of rest-motion, which are represented through the *potential-kinetic field*, should be described on the basis of the *potential-kinetic probability*. If the potential-kinetic field of *possibility* and, corresponding to it, the field of *reality*, are wave fields, then the potential-kinetic probability also must have the wave character. But in order to introduce the *wave probabilistic measure of rest-motion*, it is necessary to solve at first a so-far-unsolved problem of the *complete* potential-kinetic description of elementary harmonic oscillations.

At all levels of the Universe, rest and motion are, mainly, in a dynamic equilibrium presented in the form of *eternal wave motion*. However, classical mechanics (resting upon formal logic: only *Yes* or only *No*) was/is unable to develop a series of principal notions related to the state of rest, conjugate to the corresponding notions of the state of motion. Moreover, it describes rest and motion separately (independently). In Galilean relativity the equivalence of the notion that rest and (uniform) motion concerns the contradictory absolute-relative character of motion and rest (not considered here) and relates to the subjective choice of the frame of reference.

The introduction of the conjugate parameters makes the physics more symmetrical and complete. Indeed, there is the notion of the *displacement* of an object from the state of equilibrium; it is the *kinetic displacement*. However, there is not the notion the *potential displacement*. If we recognize that *rest and motion are the two sides of the same single process*, then the last notion has right away an existence without any doubt. This follows from the basic laws of ***dialectical philosophy and dialectical logic*** **(*dialectics*)**. Let us recall, in brief, what dialectics is. Dialectics is highly necessary for understanding the physical questions touched on in this paper, especially since most physicists are not familiar with philosophy, in general, and with dialectical philosophy, in particular.

1.2. Dialectics

Dialectics is an integral part of the foundation of world philosophy. The word "*philosophy*", in its original broad sense meaning "*the love of wisdom*", derives from the Greek compound *philosophia*, where the word *sophia* is ordinarily translated into English as "*wisdom*". According to Diogenes Laërtius (probably lived in the early part of the third century), Pythagoras (c. 570-500 B.C., an Ionian Greek born on the island of Samos) was the first to begin to call philosophy as *philosophia* (*i.e.*, the love of wisdom) and himself a philosopher (a wisdom-lover). By his words, only God can be the sage, but not a man…, and a philosopher (a wisdom-lover) is merely one who feels drawn to wisdom. Sages (and poets as well) were also called sophists (philosophizers) …

Philosophy had two origins: one with Anaximander (610-546 B.C., born in Miletus), and the other with Pythagoras. Anaximander was the "pupil and successor of Thales", and he is regarded as the founder of Greek astronomy and natural philosophy. Thales of Miletus (c. 625-547 B.C.) is the first Milesian philosopher, the founder of the antique and generally European philosophy and science, and the founder of the Ionian school of natural philosophy. He proposed a simple doctrine on the origin of the world: he asserted that all variety of things and phenomena originated from a single element – water… The first philosophy was called the Ionian philosophy; the second was called the Italian philosophy because Pythagoras was occupied with philosophy mainly in Italy.

Some philosophers were called *physicists* because they studied nature; others were referred to as *ethicists*, owing to their reasoning on morals and manners; a third group of philosophers were called ***dialecticians*** because of discussions on the justification of speech.

Physics, ethics, and dialectics are three parts of philosophy. Physics teaches about the world and all that is in it. Ethics is devoted to the life and behavior of humans. ***Dialectics*** is concerned with arguments for both physics and ethics. Until Archytas of Tarentum (a bright representative of the second-generation Pythagoreans who lived in southern Italy during the first half of the fourth century B.C.), a pupil of Anaxagoras of Clazomenae, *physics* was the only kind of philosophy. Anaxagoras of Clazomenae (who lived approximately during 500-428 B.C. and spent his most active years mainly at Athens) first taught philosophy professionally; he first advanced mind as the initiator of the physical world.

Dialectics originates with Zeno of Elea (c. 490-430 B.C.) [4]. Negating the cognition of the sensitive being, he showed in his famous paradoxes the contradictoriness of motion. Another of the founders of ***dialectics*** was also Socrates (c. 469-399 B.C.).

The word ***dialectics*** meant, on the one hand, the search for truth by conversations, which were carried out through the formulation of questions and the methodical search for answers to them. On the other hand, ***dialectics*** means the capability of vision and reflection by means of notions the *opposite facets* of nature.

In the wide sense of this word, ***dialectics*** is a skill of many-sided description of an object of thought and a logic formation of the prediction of necessary and possible events.

Thus***, dialectics is regarded as the logic of philosophy and all sciences,*** *i.e.*, as ***the logic of cognition on the whole.***

Dialectics represents a synthesis of the best achievements of both materialism and idealism and it is the ground for understanding of the material-ideal essence of the world. ***The main postulates of the dialectical philosophy*** are the following.

1. **The Postulate of Existence**

The material-ideal World ($\hat{M}$) exists. Symbolically, the material-ideal essence of the world can be briefly presented by the logical binominal

$$\hat{M} = M + iR ,$$

where M and iR are, correspondingly, material and ideal components of the world and the + sign expresses their mutual bond.

2. **The Postulate of Dialectical Contradictoriness of Evolution**

Any object or relation A in any instant is in a state of evolution, *i.e.*, it simultaneous equals and does not equal to itself:

$$(A = A) \wedge (A \neq A),$$

where $\wedge$ is the sign of logical conjunction. The following logical antinomy corresponds to the aforementioned binomial judgment:

$$(Yes = Yes) \wedge (Yes \neq Yes).$$

Dialectics states that "*A* is *A*" and "*A* is not *A*" simultaneously. For example, Smith as a child, youngster, man and old man is, on the one hand, the realization of the logical formal formula "*A* is *A*", *i.e.*, Smith is Smith. On the other hand, the child-youngster-man-old man series is the manifestation of non-tautology "*A* is not *A*", *i.e.*, Smith continuously changed and Smith as a child is not equal to Smith as a youngster. At every instant he is he, "*A* is *A*", and simultaneously he is not he, "*A* is not *A*". When we consider fast-changing physical processes at the molecular level or deeper, the truth of this postulate becomes yet more obvious.

The logical binominal of evolution "*A* is equal to *A* and, simultaneously, *A* is not equal to *A*" is beyond the bounds of formal Aristotelian rules. Aristotle (384-322 B.C.), who laid the foundation of metaphysics and formal logic, was an opponent of dialectics. He wrote [5], "There are however people which, as we pointed to, themselves speak that the same can exist and non-exist together and assert that it is impossible to hold this point of view. Many among explorers of nature turn to this thesis." According to metaphysics, two formally logical judgments *A* (*Yes*) and *A* (*Yes*) are always assumed to be *only equal* through the *law of identity*: A=A (*Yes* = *Yes*). This tautology excludes any possibility of motion and analysis, and if humans followed this rule in fact, the development of human thought would be impossible.

3. The postulate of Affirmation of Dialectical Logic

(a) A brief dialectical judgment about an object of thought is presented, in a general case, by the symmetrically asymmetric logic structure *Yes-No* or *No-Yes*. (b) Relatively symmetric objects are expressed by the logical structure *Yes-Yes*, or briefly *Yes*, and relatively asymmetric by the structure *No-No*, or briefly *No*. (c) In a general case, a logical dialectical judgment L is the function of the elementary judgments *Yes* and *No*,

$$L = f(Yes, No).$$

Cognition of the World proceeds on the basis of comparison and through comparison. In the first approximation any element of a state or a phenomenon of nature has at least two sides of comparison. This requires us to describe A by dialectical symmetrically asymmetric judgments of the kind *Yes-No*. The last presents the symmetrical pair of judgments *Yes* and

No, which are in essence the opposite judgments, so that in this sense both these judgments are asymmetric ones.

In a general case, *Yes* and *No* are natural judgments about an object of study. They express *quantitative* and *qualitative* measures of the object. Here are some examples of polar-opposite notions: rest-motion, potential-kinetic, continuous-discontinuous, absolute-relative, existence-nonexistence, material-ideal, form-contents, basis-superstructure, qualitative-quantitative, cause-effect, objective-subjective, past-future, necessary-causal, finite-infinite, real-imaginary, wave-quantum, particle-antiparticle.

Chuang Tzu (c. 369-286 B.C., an outstanding representative of Taoism) has written (Ref. [2], p. 215), "In the World, everything ***denies*** itself through the other thing, which is its opposition. Every thing states itself through itself. It is impossible to discern (in the one separately taken thing) its opposition, because it is possible to perceive a thing only immediately. This is why, they say: "***Negation*** issues from ***affirmation*** and affirmation exists only owing to negation." Such is the doctrine on the conditional character of negation and affirmation. If this is so, then all dies already being born and all is born already dying; all is possible already being impossible and all is impossible already being possible. Truth is only insomuch as, inasmuch as lie exists, and lie is only insomuch as, inasmuch as truth exists. The above stated is not an invention of a sage, but it is the fact that is observed in nature…".

Another Chinese philosopher Ch'eng Hao (1032-1085) has said (Ref. [3], p. 327): "The highest principle for all things in heaven and on the Earth is that there is not one single thing that is independent, because, it is obligatory, there is its ***opposite***…". In other words, ***all things do not represent a single whole, but these exist in the form of opposites***. His brother Ch'eng I (1033-1107) has stated: "Everything in the space between heaven and the Earth has opposites; if there is the Dark Beginning then the Light One also is; if well is, hence evil is as well", *etc*.

For the description of the *opposite* properties of objective reality it is convenient to use *complex numbers*, as the numbers with polar opposite algebraic properties [6]. The transformation of the kinetic field into the potential one, or the *electric* field into the *magnetic* one, means (in the language of complex numbers) the transformation of the "*real*" numerical field into the "*imaginary*" one, and *vice versa*.

Thus, as follows from the basic law of dialectics *Yes-No* (the law of symmetry and asymmetry *Yes* and *No* of the polar judgments), ***motion-rest must be described by the conjugate symmetrical parameters***. Disregard of the law leads, to put it mildly, to disagreeable consequences for science (see, *e.g.*, Ref. [7]).

Correspondingly, the *kinetic speed* (the first time derivative of kinetic displacement) as the speed of change of motion must be conjugate with the *potential speed* of change of rest. This supposes the supplementation of the *kinetic momentum* with the *potential momentum*. We must operate also with the *potential* and *kinetic force* and *potential* and *kinetic work*, along with the already-existed *potential* and *kinetic energy*. Contemporary physics did not develop the notion of the *potential-kinetic wave field*, which could be regarded as a generalized image of any real physical field (electromagnetic, for example).

It is natural, the above problems also concern the description of the *field of physical (real) time* (an *ideal field-space* of the Universe), which enters in the triad of *matter-space-time* and differs from the *reference* (mathematical) *time* used everywhere.

The goal of this paper is an introduction of the above-mentioned missing conjugate notions (parameters) analyzing harmonic oscillations of a material point.

2. Potential-kinetic parameters of harmonic oscillations

2.1. Displacement

In dialectical logic and philosophy, consequently, in physics as well, the judgment *Yes* is the qualitative measure of affirmation, as such. Concerning its quantitative measure, the last is defined by the measures of studying processes and objects. The implicit dialectical symbol *Yes* is represented by the symbol of the physical quantity, which the symbol *Yes* expresses logically.

Since properties of the processes and objects, expressed by the judgment *Yes*, in a general case are variable ones, the dialectical judgment *Yes* is a variable quantity, represented by a function of its arguments. For example, if *Yes* expresses some displacement of a material point, then the value *Yes* is equal to the value of the displacement itself. Let a kinetic displacement of a material point *Yes* be its displacement from the state of equilibrium and defined as

$$Yes = a\cos\omega t\,. \tag{2.1}$$

Following the requirement of symmetry, conditioned by the dialectical law *Yes-No*, one should introduce the notion that will be opposite to the notion of the *kinetic displacement*, *Yes*. It is natural to term it the *potential displacement*, *No*. The displacement *No*, as the *negation* of the kinetic displacement *Yes*, can be described by the sine function, since *sine is the negation of cosine*, just as *cosine is the negation of sine*. It is natural to accept amplitude of the potential displacement as equal to the amplitude of the kinetic displacement. Apart from this, we will present the potential displacement as the negation of the kinetic one by the ideal number. Thus, in the capacity of the potential displacement, we accept the following measure:

$$No = ia\sin\omega t\,. \tag{2.2}$$

Both displacements, reflecting the indissoluble bond of rest and motion, constitute the *potential-kinetic displacement* $\hat{\Psi}$, which we present in the following form:

$$\hat{\Psi} = Yes + No\,. \tag{2.3}$$

If we denote the kinetic displacement *Yes* as x_k and the potential displacement *No* as ix_p, we will obtain the following dialectical expression for the potential-kinetic displacement (Fig. 2.1):

$$\hat{\Psi} = x_k + ix_p \quad \text{or} \quad \hat{\Psi} = a\cos\omega t + ia\sin\omega t\,. \tag{2.4}$$

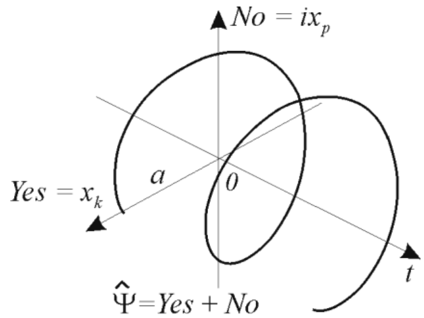

Fig. 2.1. A graph of the potential-kinetic displacement *Yes* – *No*.

The kinetic displacement is the possibility of the potential displacement, and, conversely, the potential displacement is the possibility of the kinetic displacement. When a material point passes through the equilibrium state, its motion is more intensive (the maximum of motion takes place). After passing equilibrium, the intensity of motion falls and, simultaneously, it increases the extent of rest, expressed through the growing value of the potential displacement. Using Euler's equations, we present the potential-kinetic harmonic displacement as

$$\hat{\Psi} = ae^{i\omega t}. \tag{2.4a}$$

The constant component of the potential-kinetic displacement is expressed by the amplitude *a*, and the variable component is expressed by the ideal exponential function. The ideal exponential function $e^{i\omega t}$ is also the relative measure of displacement, and its fundamental quantum of qualitative changes is

$$e^{i\omega t} = \frac{\hat{\Psi}}{a}. \tag{2.5}$$

And, because the relation (2.5) is valid for all harmonic potential-kinetic measures, all these measures have (in the capacity of a relative measure) the ideal exponential function. In this sense, their relative measures are turned out to be equal between themselves.

2.2. Speed and acceleration

The potential-kinetic displacement defines the potential-kinetic speed

$$\hat{\upsilon} = \frac{d\hat{\Psi}}{dt} = \upsilon_k + i\upsilon_p, \tag{2.6}$$

where

$$\upsilon_k = i\omega \cdot ix_p = -\omega x_p \tag{2.6a}$$

is the kinetic speed, *i.e.*, the speed of change of motion, and

$$i\upsilon_p = i\omega \cdot x_k \tag{2.6b}$$

is the potential speed, *i.e.*, the speed of change of rest.

Amplitude, or a module of speed, as the total speed, is the constant equal to

$$\upsilon = \omega a\,. \tag{2.6c}$$

As follows from the formulas (2.6a) and (2.6b), the kinetic speed is connected with the potential displacement, whereas the potential speed is defined by the kinetic displacement.

The potential-kinetic speed defines the potential-kinetic acceleration

$$\hat{w} = \frac{d\hat{\upsilon}}{dt} = -\omega^2 (x_k + ix_p) = w_k + iw_p\,, \tag{2.7}$$

where

$$w_k = -\omega^2 x_k \tag{2.7a}$$

is the kinetic acceleration, *i.e.*, the speed of change of the kinetic speed, and

$$iw_p = -\omega^2 \cdot ix_p \tag{2.7b}$$

is the potential acceleration, *i.e.*, the speed of change of the potential speed.

2.3. State

In the potential-kinetic field, a displacement $\hat{\Psi}$ characterizes a *potential-kinetic state* $\hat{S}$ *of a material point*. We define this state through the product of its mass and the displacement:

$$\hat{S} = m\hat{\Psi} = s_k + is_p\,, \tag{2.8}$$

where

$$s_k = mx_k \qquad \text{and} \qquad is_p = mx_p \tag{2.8a}$$

are, correspondingly, the kinetic and potential states of a material point in the harmonic motion.

The state of a material point $\hat{S}$ expresses the indissolubility of its mass m and displacement $\hat{\Psi}$, i.e., the indissolubility of matter and space (which is reflected in its writing as matter-space). The potential-kinetic harmonic state can also be presented in the following forms

$$\hat{S} = me^{i\omega t}a = (m\cos\omega t + im\sin\omega t)a = (m_k + im_p)a = \hat{m}a = s_k + is_p\,, \tag{2.9}$$

where

$$\hat{m} = me^{i\omega t} = m_k + im_p \qquad (2.9a)$$

is the *kinematic potential-kinetic mass* of a material point in the harmonic oscillation.

2.4. Charge and current

The measure of the speed of change of the potential-kinetic state of mass $\hat{m}$ in the oscillating process is call the *kinematic charge* $\hat{Q}$. According to this definition, the potential-kinetic mass $\hat{m}$ and the *kinematic potential-kinetic charge* $\hat{Q}$ are related as

$$\hat{Q} = \frac{d\hat{m}}{dt} = i\omega\hat{m} \qquad (2.10)$$

and, modulo, as

$$q = \omega m . \qquad (2.10a)$$

The kinematic potential-kinetic charge defines the *kinematic potential-kinetic current*

$$\hat{I} = \frac{d\hat{Q}}{dt} = \frac{d^2\hat{m}}{dt^2} = i\omega\hat{Q} = -\omega^2\hat{m} \qquad (2.11)$$

with the amplitude

$$I = \omega q = \omega^2 m . \qquad (2.11a)$$

The amplitude of the kinematic current (2.11a) is called the *elasticity* coefficient *k*. This name relates the amplitude of kinematic current with the *biological sensation* of exchange of motion-rest. It is analogous to such terms as heat, force, and "fluid" (once used in physics and, actually, related to the molecular level of exchanges of motion-rest). Notions of dialectical physics are the notions of exchange of matter-space and motion-rest. We will denote the amplitude of the kinematic current (2.11a) by the symbol *k* as well.

2.5. Momentum and force

The potential-kinetic state $\hat{S}$ defines the field of the *potential-kinetic momentum Yes-No*:

$$\hat{P} = \frac{d\hat{S}}{dt} = m\hat{\upsilon} = m(\upsilon_k + i\upsilon_p) = p_k + ip_p , \qquad (2.12)$$

where p_k and ip_p are the kinetic and potential momenta. The momentum *Yes* is the kinetic momentum

$$p_k = m\upsilon_k = mi\omega ix_p = -m\omega x_p , \qquad (2.12a)$$

whereas the momentum *No* is the potential momentum

$$ip_p = mi\upsilon_p = mi\omega x_k\,. \qquad (2.12b)$$

Thus the kinetic momentum is related to the potential displacement and the potential momentum to the kinetic displacement. The field of the $\hat{P}$ -momentum is *the field of motion-rest of the first level* with respect to the $\hat{S}$ -state.

The field of potential-kinetic momentum defines the field of *the potential-kinetic rate of exchange of momentum* $\hat{F}$ (*force*):

$$\hat{F} = \frac{d\hat{P}}{dt} = f_k + if_p = m\hat{w} = m(w_k + iw_p) = -I\hat{\Psi}\,, \qquad (2.13)$$

where

$$f_k = \frac{dp_k}{dt} = mw_k = -kx_k = Ix_k \qquad (2.13a)$$

is the kinetic rate of exchange of motion, expressed by the kinetic momentum, and

$$if_p = \frac{dip_p}{dt} = miw_k = -kix_p = -Iix_p \qquad (2.13b)$$

is the potential rate of exchange of rest, defined by the potential momentum.

The rate of exchange $\hat{F}$ is the *field of motion-rest of the second level* with respect to the $\hat{S}$ -state and, at the same time; it is the state of exchange, defined by the kinematic current.

2.6. Energy

As follows (2.13),

$$I = -\frac{\partial\hat{F}}{\partial\hat{\Psi}}\,, \qquad \hat{\Psi} = -\frac{\partial\hat{F}}{\partial I}\,. \qquad (2.14)$$

The integral

$$\hat{A} = -\int_0^t \hat{F}d\hat{\Psi} = \left.\frac{I\Psi^2}{2}\right|_0^t = \frac{I\Psi^2}{2} - \frac{I\Psi_0^2}{2} \qquad (2.15)$$

defines the kinematic work $\hat{A}$, and the kinematic energy $\hat{E}$ is defined by:

$$\hat{E} = \frac{I\Psi^2}{2} = \frac{k(x_k + ix_p)^2}{2} = \frac{kx_k^2}{2} - \frac{kx_p^2}{2} + ikx_k x_p\,. \qquad (2.16)$$

The first and second components of energy (2.16) are the *kinetic* and *potential* energies

$$E_k = \frac{p_k^2}{2m} = \frac{m\upsilon_k^2}{2} = \frac{kx_p^2}{2}, \qquad E_p = -\frac{p_p^2}{2m} = -\frac{m\upsilon_p^2}{2} = -\frac{kx_k^2}{2}. \qquad (2.16a)$$

The third component is the sum of *potential-kinetic* and *kinetic-potential* energies:

$$E_{pk} = \frac{kix_p x_k}{2}, \qquad E_{kp} = \frac{kx_k ix_p}{2}. \qquad (2.16b)$$

Thus, following dialectics, the kinetic energy is represented by four components: the *kinetic* energy *Yes-Yes,* the *potential* energy *No-No,* the *potential-kinetic* energy *No-Yes,* and the *kinetic-potential* energy *Yes-No*. These components logically represent the major quaternion of dialectical judgments/laws: *Yes-Yes, Yes-No, No-Yes, and No-No.*

The potential displacement $ix_p = ia\sin\omega t$ defines the kinetic energy and the kinetic displacement $x_k = a\cos\omega t$ defines the potential energy. Thus the potential displacement, as the potential displacement, is simultaneously the kinetic displacement in the sense that it defines the kinetic energy and the extremum of the state of motion. Just so, the kinetic displacement, as the kinetic displacement, is simultaneously the potential displacement in the sense that it defines the potential energy and the extremum of the state of rest.

There is direct evidence of the dialectical contradiction, expressed by the law *Yes-No*. For this reason we can rename the potential displacement as the kinetic displacement and denote it as $ix_k = ia\sin\omega t$, and, similarly, the kinetic displacement as the potential displacement and denote it as $x_p = a\cos\omega t$. At such definitions of displacements the formulas of kinetic and potential displacements, speeds, and energies will take the following form:

$$\hat{\Psi} = x_p + ix_k = a\cos\omega t + ia\sin\omega t,$$

$$\upsilon_k = \frac{dx_p}{dt} = -\omega a\sin\omega t = i\omega ix_k, \qquad i\upsilon_p = \frac{dix_k}{dt} = i\omega a\cos\omega t = i\omega x_p, \qquad (2.17)$$

$$E_k = \frac{p_k^2}{2m} = \frac{m\upsilon_k^2}{2} = \frac{kx_k^2}{2}, \qquad E_p = -\frac{p_p^2}{2m} = -\frac{m\upsilon_p^2}{2} = -\frac{kx_p^2}{2}.$$

As we see, it is impossible to avoid dialectics of the law *Yes-No* by changing the names of the measures into opposite ones. Now the kinetic speed of motion is the derivative of the potential displacement and, conversely, the potential speed is the derivative of the kinetic displacement. For this reason, if it is necessary to distinguish rest or motion, we will use the conjugated kinetic or potential terms.

At the *circular* motion-rest, the energy on the basis of vector measures [1] is

$$\hat{E} = \int \hat{\mathbf{F}} d\hat{\mathbf{r}} = \int m\hat{\mathbf{v}} d\hat{\mathbf{v}} = -\int I\hat{\mathbf{r}} d\hat{\mathbf{r}} = -\frac{k\hat{\mathbf{r}}^2}{2} = \frac{m\hat{\mathbf{v}}^2}{2}, \qquad (2.18)$$

or

$$\hat{E} = \frac{m\mathbf{v}_k^2}{2} + \frac{m\mathbf{v}_p^2}{2} + \frac{2m\mathbf{v}_k\mathbf{v}_p\cos\alpha}{2} = \frac{m\upsilon^2}{2} + \frac{m(i\upsilon)^2}{2} + \frac{2m\mathbf{v}_k\mathbf{v}_p\cos(\pi/2)}{2} = 0, \qquad (2.19)$$

where (see Fig. 2.2)

$$\hat{\mathbf{v}} = \frac{d\hat{\mathbf{r}}}{dt} = \hat{\mathbf{v}}_k + \hat{\mathbf{v}}_p = \upsilon\boldsymbol{\tau} + i\upsilon\mathbf{n} \qquad \text{or} \qquad \hat{\mathbf{v}} = \frac{d\hat{\mathbf{r}}}{dt} = \omega r\boldsymbol{\tau} + i\omega r\mathbf{n}, \qquad (2.20)$$

$\upsilon = \omega r$ and $\hat{\mathbf{v}}_k = d\hat{\mathbf{r}}_p / dt = \upsilon\boldsymbol{\tau}$ is the kinetic tangential velocity, $\hat{\mathbf{v}}_p = d\hat{\mathbf{r}}_k / dt = i\upsilon\mathbf{n}$ is the potential normal velocity.

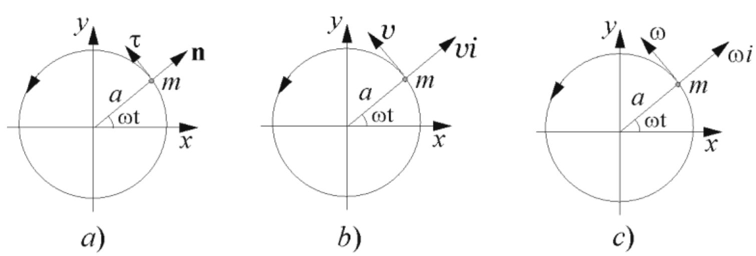

Fig. 2.2. The kinematics of motion-rest along a circumference: *a*) the tangential $\boldsymbol{\tau}$ and normal $\mathbf{n}$ units vectors; *b*) $\mathbf{v}_p = i\omega a\mathbf{n} = i\upsilon\mathbf{n}$ is the potential velocity, $\mathbf{v}_k = \omega a\boldsymbol{\tau} = \upsilon\boldsymbol{\tau}$ is the kinetic velocity; *c*) $\boldsymbol{\omega}_p = i\omega\mathbf{n}$ is the potential specific velocity, $\boldsymbol{\omega}_k = \omega\boldsymbol{\tau}$ is the kinetic specific velocity.

According to the above and the theory of oscillations of a string and the theory of circular motion [1], the energetic measures of rest and motion are represented by the opposite, in sign, but equal in value, *kinetic* and *potential energies*. Because an insignificant part of an arbitrary trajectory is equivalent to a small part of a straight line, *any wave motion* of an arbitrary microparticle (and, to an equal degree, a macro- and megaobject) *is characterized by the kinetic and potential energies,* also equal in value and opposite in sign:

$$E_k = \frac{m\upsilon_k^2}{2}, \qquad E_p = \frac{m(i\upsilon)_p^2}{2} = -\frac{m\upsilon_p^2}{2}. \qquad (2.21)$$

Therefore the total potential-kinetic energy of any object in the Universe is equal to zero:

$$E = E_k + E_p = 0\,, \qquad (2.22)$$

and its amplitude is equal to the difference in kinetic and potential energies:

$$E_m = E_k - E_p = m\upsilon^2\,. \qquad (2.23)$$

Under the motion along a circumference (as in particular takes place with the electron in the H atom), the potential-kinetic vector energy of a material point is equal to zero. By virtue of this, the circular motion is the optimal (equilibrium) state of the field of rest-motion, where "attraction" and "repulsion" are mutually balanced, which, in turn, provide for the steadiness of orbital motion in the micro- and macroworld.

The *quantitative equality* of "attraction" and "repulsion" is accompanied, simultaneously, by the *qualitative inequality* of the *directions* of fields of rest and motion, which generates the eternal circular wave motion. In order to break such a motion, it is necessary to destroy this system entirely. However, in this case, a vast number of new circular wave motions of more disperse levels will appear as a result.

3. Physical time

The wave $\hat{\Psi}$ function,

$$\hat{\Psi} = \hat{R}(r)\Theta(\theta)\hat{\Phi}(\varphi)T(t) = \hat{\psi}(r,\theta,\varphi)\hat{T}(t)\,,$$

satisfying the ordinary wave equation

$$\Delta\hat{\Psi} = \left(\frac{1}{\upsilon_0^2}\right)\frac{\partial^2\hat{\Psi}}{\partial t^2}\,,$$

describing arbitrary periodic processes running in space and time, is the mathematical expression of the indissoluble bond of the fields of material space and physical time. The time function $\hat{T}(\omega t)$ (its simplest solution is $T = e^{\pm i\omega t}$) expresses the *alternating physical time field* by means of the variable *t*, which represents the *ideal mathematical time* of the imaginary absolute uniform motion. The real times of natural processes are compared with this mathematical time. We call mathematical time the *absolute* or *reference time*.

The *real* (*physical*) *time*, as the measure of pure motion-rest, must also be *potential-kinetic*. Let us show this. By analogy with the absolute time

$$t = \frac{l}{\upsilon},$$

the *physical time of harmonic oscillations* $\hat{t}$ is defined as the ratio of the *potential-kinetic* displacement $\hat{\Psi}$ to the module of potential-kinetic speed υ:

$$\hat{t} = \frac{\hat{\Psi}}{\upsilon} = \frac{ae^{i\omega t}}{\omega a} = t_m e^{i\omega t} = t_k + it_p. \tag{3.1}$$

In this expression, $t_m = 1/\omega = T/(2\pi)$ is the module of the potential-kinetic time. The *kinetic* and *potential times,*

$$t_k = t_m \cos\omega t \qquad \text{and} \qquad it_p = it_m \sin\omega t \tag{3.2}$$

are functions of the uniform mathematical time *t*. In the capacity of the basic unit of physical time, we accept the *second* of the absolute time.

The physical time allows the more complete description of the *dialectically contradictory potential-kinetic processes*. The physical time is the time of the logical structure *Yes-No*. As follows from the definition of physical time,

$$\hat{\Psi} = \upsilon\hat{t}, \qquad x_k = \upsilon t_k, \qquad ix_p = \upsilon it_p. \tag{3.3}$$

The physical time repeats the form of the potential-kinetic displacement. The equations of displacements (3.3), defined by the physical time, are similar, in form, to the equation of displacement *l* in the uniform motion on the basis of reference time *t*:

$$l = \upsilon t. \tag{3.4}$$

By analogy with the relations between contents and form, we express the relations between the extension of space and the duration of time through the speed as

$$\upsilon = \upsilon_0 \upsilon_r, \tag{3.5}$$

where $\upsilon_0 = 1\,cm/s$ is the absolute unit speed and υ_r is the relative speed.

We also introduce the "inverse speed" ς according to the equality

$$\varsigma = \frac{1}{\upsilon} = \varsigma_0 \varsigma_r, \tag{3.6}$$

where $\varsigma_0 = 1\,s/cm$ is the absolute unit of the inverse speed and ς_r is the relative inverse speed.

Resting upon (3.5) and (3.6), we can rewrite the equation of displacement (3.4) in two ways:

$$l = \upsilon_0 \upsilon_r t\,, \qquad t = \varsigma_0 \varsigma_r l\,. \tag{3.7}$$

Analogously, we express the relation between the displacement $\hat{\Psi}$ and time $\hat{t}$:

$$\hat{\Psi} = \upsilon_0 \upsilon_r \hat{t}\,, \qquad \hat{t} = \varsigma_0 \varsigma_r \hat{\Psi}\,. \tag{3.8}$$

The physical potential-kinetic time of harmonic oscillations in wave processes is the *wave time field*. It also is the *ideal space of matter*. Just this *wave potential-kinetic time field enters in the dialectical triad matter-space-time.* The physical time of harmonic oscillations $\hat{t} = t_m e^{i\omega t} = t_k + it_p$ runs nonuniformly with the *time potential-kinetic speed*

$$\hat{\xi} = \frac{d\hat{t}}{dt} = ie^{i\omega t} = \xi_k + i\xi_p\,, \tag{3.9}$$

Where

$$\xi_k = \frac{dt_k}{dt} = -\omega t_m \sin\omega t = -\sin\omega t \tag{3.9a}$$

and

$$i\xi_p = \frac{dit_p}{dt} = i\omega t_m \cos\omega t = i\cos\omega t \tag{3.9b}$$

are the *kinetic and potential time speeds*, correspondingly.

The derivative of any $\hat{\Psi}$ function (describing an arbitrary physical field) with respect to some argument ζ defines a new field $\hat{\Xi} = d\hat{\Psi}/d\zeta$. This field is the *field of negation of the initial field*. Correspondingly, the derivative $d\hat{\Xi}/d\zeta$ defines the field of negation of the field $\hat{\Xi}$, *etc*. Thus, the field of the second derivative $\hat{\Sigma} = d^2\hat{\Psi}/d\zeta^2$ of $\hat{\Psi}$-function is the *field of negation of negation* of the $\hat{\Psi}$ field, or the *field of double negation* $\hat{\Sigma}$.

In such a case the field, defined by the derivative $\hat{\xi} = d\hat{t}/dt$, represents by itself the *field of negation of the field of physical time*. This new field is the *time field of potential-kinetic motion of time*. As such, it is the *quantitative-qualitative field of the Universe, because quantity and quality exist objectively in it.* Its subjective image is the dialectical numerical field of affirmation-negation *Yes-No* [6]. The quantitative-qualitative field of change of the physical time is simultaneously the material-ideal field, because quantity and quality are in the same relation, as material and ideal.

The space and time speeds are related by the following equalities:

$$\hat{\upsilon} = \upsilon_m \hat{\xi}, \qquad \upsilon_k = \upsilon_m \xi_k\,, \qquad i\upsilon_p = i\upsilon_m \xi_p\,. \tag{3.10}$$

The kinetic and potential energies, expressed with use of time speeds, have the form

$$E_k = E_m \xi_k^2, \qquad E_p = E_m \xi_p^2, \tag{3.11}$$

where $E_m = m\upsilon_m^2 / 2$ is the amplitude of kinematic energy.

4. The wave equation of time field-space

The potential-kinetic parameters of oscillations have the universal character and are applied to any potential-kinetic waves of matter-space-time. Relative measures $\hat{\psi}_r$ of all potential-kinetic parameters of harmonic oscillations of equal frequencies, expressed through amplitudes, are equal to the same ideal exponential function

$$\hat{\psi}_r = \frac{\hat{\Psi}}{a} = e^{i\omega t}. \tag{4.1}$$

In this sense, all these measures are identical.

For the description of *waves* of different nature, the *wave spatial vector* **k**, related to the basis of the wave, is used. It is determined by the equality

$$\mathbf{k} = \left(\frac{2\pi}{\lambda}\right)\mathbf{n} = \left(\frac{1}{\lambda\!\!\!^{-}}\right)\mathbf{n}, \tag{4.2}$$

where **n** is the unit vector directed along the wave extension, λ is the length of the spatial wave, and $\lambda\!\!\!^{-}$ is the wave radius. We supplement the **k**-vector with the analogous *wave time vector* **ω,** conjugated to **k**,

$$\boldsymbol{\omega} = \left(\frac{2\pi}{T}\right)\mathbf{n} = \left(\frac{1}{t_m}\right)\mathbf{n}. \tag{4.3}$$

Comparing the vectors, (4.2) and (4.3), we see that, at the level of the basis of time waves, the period T is the *time wave* conjugated to the *space wave* λ.

The module of physical potential-kinetic time t_m (see (3.1)) is the radius of time circumference T ($T = 2\pi t_m$), whereas in wave processes it is the wave time radius (compare $\lambda\!\!\!^{-}$ and t_m in (4.2) and (4.3)). The vectors **k** and **ω** are connected through the equality:

$$\boldsymbol{\omega} = c\mathbf{k} = c_0 c_r \mathbf{k}, \tag{4.3a}$$

where $c = c_0 c_r$ is the basis wave speed, $c_0 = 1\,cm/s$ is the unit speed, and c_r is the relative speed. Thus the physical time of uniform motion, equivalent to the reference time, is contradictory: being the scalar magnitude it is simultaneously the vector magnitude.

For the description of the physical time field-space we use the reference rectangular three-dimensional space of the absolute time. Namely, we present it by the frame of reference with the time axes T_x, T_y, and T_z. If a spatial wave beam of harmonic potential-kinetic oscillations $\hat{\Psi}$, with a constant amplitude a, is travelling along the x axis, then its equation has the form

$$\hat{\Psi} = ae^{i(\omega t - kx)}. \quad (4.4)$$

The following wave beam of harmonic potential-kinetic oscillations of time field $\hat{t}$ corresponds to it:

$$\hat{t} = t_m e^{i(\omega t - kx)}. \quad (4.5)$$

Harmonic beams with arbitrary constant amplitudes and equal frequencies are conjugated to the time wave beam of the same amplitude t_m. This amplitude is expressed through the amplitude of its own oscillatory speed, *i.e.*, the speed of superstructure. In view of this the measure of the amplitude of the time harmonic wave does not reflect the measure of the amplitude of the conjugated spatial wave.

In order to make the time amplitude reflect the measure of the spatial amplitude, we should introduce the *relative time amplitude* τ_m equal, by the definition, to the ratio of spatial amplitude a to the unit linear speed-density $c_0 = 1\,cm/s$:

$$\tau_m = \frac{a}{c_0}. \quad (4.6)$$

Now we can accept, as the measure of the time wave, the product of the relative time amplitude τ_m and the relative measure of the beam-wave $\hat{\psi}_r$:

$$\hat{\Psi}_m = \tau_m \hat{\psi}_r = \tau_m e^{i\omega t}. \quad (4.7)$$

If waves of the kind

$$\hat{\Psi} = \tau_m e^{i(\omega t - kr)} \quad (4.8)$$

arise along the three axes of Cartesian coordinates x, y, z, the following time three-dimensional wave field-space is formed

$$\hat{T} = \tau_{xm} e^{i(\omega_x t_x - k_x x)} \tau_{ym} e^{i(\omega_y t_y - k_y y)} \tau_{zm} e^{i(\omega_z t_z - k_z z)}, \quad (4.9)$$

where ω_x, ω_y, ω_z are components of the time wave vector $\boldsymbol{\omega}$ and t_x, t_y, t_z are components of the vector of absolute time $\boldsymbol{t}$.

Fields-spaces of the structure (4.9) are *multiplicative* fields-spaces because spatial and time waves (components) in it are multiplicatively linked together. In other words, the principle of multiplicative superposition is valid for such fields. These are spaces-systems, or *atomic spaces* [1]. The sums of the multiplicative atomic fields-spaces form complicated fields-spaces, which can be called *molecular spaces*. These are *additive fields-spaces*, since the principle of additive superposition is valid for them.

The wave function $\hat{\Psi}$ of the three-dimensional wave field of physical time is the mathematical image-measure of the wave three-dimensional time space. The three-dimensional time wave is represented by its multiplicative components-waves:

$$\hat{\Psi}_x = \tau_{xm} e^{i(\omega_x t_x - k_x x)}, \qquad \hat{\Psi}_y = \tau_{ym} e^{i(\omega_y t_y - k_y y)}, \qquad \hat{\Psi}_z = \tau_{zm} e^{i(\omega_z t_z - k_z z)}. \tag{4.10}$$

Because $\boldsymbol{\omega}\mathbf{t} = \omega_x t_x + \omega_y t_y + \omega_z t_z$, the $\hat{T}$-image of the three-dimensional wave (4.9) can be presented as

$$\hat{T} = \tau_{xm}\tau_{ym}\tau_{zm} e^{i(\omega t - k_x x - k_y y - k_z z)} \qquad \text{or} \qquad \hat{T} = T_m e^{i(\omega t - k_x x - k_y y - k_z z)}. \tag{4.11}$$

In a general case the wave amplitude is variable and, in the wave stationary field, depends on coordinates, so we express it in the following way

$$\hat{T} = T_m(k_x x, k_y y, k_z z)e^{i(\omega t - k_x x - k_y y - k_z z)}. \tag{4.12}$$

Assuming that the amplitude T_m is a constant within the space of a material point, we have

$$\frac{\partial^2 \hat{T}}{\partial x^2} = -k_x^2 \hat{T}, \qquad \frac{\partial^2 \hat{T}}{\partial y^2} = -k_y^2 \hat{T}, \qquad \frac{\partial^2 \hat{T}}{\partial z^2} = -k_z^2 \hat{T} \qquad \text{and}$$

$$\frac{\partial^2 \hat{T}}{\partial x^2} + \frac{\partial^2 \hat{T}}{\partial y^2} + \frac{\partial^2 \hat{T}}{\partial z^2} = -k^2 \hat{T}.$$

This equation can be also presented as

$$\frac{\partial^2 \hat{T}}{\partial (kx)^2} + \frac{\partial^2 \hat{T}}{\partial (ky)^2} + \frac{\partial^2 \hat{T}}{\partial (kz)^2} = -\hat{T} \qquad \text{or} \qquad \nabla_k \nabla_k \hat{T} = \Delta_k \hat{T} = -\hat{T}, \tag{4.13}$$

where

$$\nabla_k = \frac{\partial}{\partial kx}\mathbf{i} + \frac{\partial}{\partial ky}\mathbf{j} + \frac{\partial}{\partial kz}\mathbf{k} \tag{4.14}$$

is the vector of the negation of the time $\hat{\Psi}$ field and

$$\nabla_k \nabla_k = \nabla_k^2 = \Delta_k = \frac{\partial^2}{\partial (kx)^2} + \frac{\partial^2}{\partial (ky)^2} + \frac{\partial^2}{\partial (kz)^2} \tag{4.15}$$

is the operator of negation of negation, or the *operator of double negation*. In essence, the equation

$$\nabla_k \nabla_k \hat{T} = -\hat{T} \quad \text{or} \quad \Delta_k \hat{T} = -\hat{T}\,, \tag{4.16}$$

is the *differential expression of the dialectical law of negation of negation*:

$$\mathbf{NoNo}\mathit{Yes} = -\mathit{Yes}\,, \quad \text{or} \quad \mathbf{No}^{\mathbf{2}}\mathit{Yes} = -\mathit{Yes}\,, \tag{4.17}$$

where *Yes* is a judgement about $\hat{T}$, i.e., $\mathit{Yes} = \hat{T}$, and $\mathbf{No} = \nabla_k$.

Thus *the wave equation of time field-space* (4.16) *is one of the forms of the universal law of dialectics – the law of negation of negation, or double negation.*

Since

$$\frac{\partial^2 \hat{T}}{\partial (\omega t)^2} = -\hat{T} \quad \text{or} \quad \frac{\partial^2 \hat{T}}{\partial \tau^2} = -\hat{T}\,,$$

where $\tau = \omega t$ is the relative linear reference time, corresponding to the relative reference distance $\rho = kr$, the equation (4.13) can be presented in the following form

$$\frac{\partial^2 \hat{T}}{\partial \rho_x^2} + \frac{\partial^2 \hat{T}}{\partial \rho_y^2} + \frac{\partial^2 \hat{T}}{\partial \rho_z^2} = \frac{\partial^2 \hat{T}}{\partial \tau^2}\,. \tag{4.18}$$

This equation means the equality of time double and spatial double negations of the $\hat{T}$-image of the physical wave time field-space. Because

$$\nabla\nabla = \nabla^2 = \Delta = \frac{\partial^2}{\partial\rho_x^2} + \frac{\partial^2}{\partial\rho_y^2} + \frac{\partial^2}{\partial\rho_z^2},$$

the wave equation (4.18) can be written as

$$\Delta\hat{T} = \frac{\partial^2\hat{T}}{\partial\tau^2}. \tag{4.19}$$

In the language of dialectical logic (4.19) represents the laws of double spatial and double time negations:

$$\mathbf{No}_\rho^2\hat{T} = \mathbf{No}_\tau^2\hat{T} = -\hat{T}, \tag{4.20}$$

where

$$\mathbf{No}_\rho^2 = \nabla^2 = \Delta, \qquad \mathbf{No}_\tau^2 = \partial^2/\partial\tau^2 \tag{4.21}$$

are the logical operators of double spatial and double time negations, correspondingly.

The physical wave time field-space is inseparable from the wave field of space of matter of the same structure, because the time wave $\hat{T}$ repeats the structure of spatial waves $\hat{\Psi}$ (compare $\Delta\hat{\Psi} = \partial^2\hat{\Psi}/\partial\tau^2$ with (4.19)).

5. Conclusion

1. The kinetic-potential parameters of displacement, speed, acceleration, state, momentum, force, energy, charge, and current were first introduced for the description of harmonic oscillations. These symmetrical binary potential-kinetic parameters give the more complete description of potential-kinetic fields of any nature.

2. The introduced parameters of oscillations have the universal character and are applied to any potential-kinetic waves of matter-space-time. At that, we should mention one result especially: it was shown that the total potential-kinetic energy of any object in the Universe is equal to zero.

3. The difference between reference (mathematical) time and physical (real) time has been revealed. The physical time wave field is an ideal field-space of the Universe. *Just physical time enters in the triad of matter-space-time*. For its description the notions of the wave potential-kinetic time field and corresponding time potential-kinetic parameters were introduced. The wave time vector $\boldsymbol{\omega}$ was introduced (conjugated to the wave vector $\mathbf{k}$) to allow us to consider the period T as the time wave conjugated to the spatial wave λ.

4. The wave function of the three-dimensional wave field of physical time, as the mathematical image-measure of the wave three-dimensional time space, satisfies the wave equation of time field-space. This equation reflects the universal law of dialectics – the law of double negation. The physical wave time field-space is inseparable from the wave field of

space of matter of the same structure, because the time wave repeats the structure of spatial waves.

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