The Undular Model as Basis for Long-Range Ordered Structures

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Abstract — **As a result of research of wave function properties it was found that the waves form stable states of arbitrary complexity and this allows to admit that wave functions can serve as a physical basis for an algebra of self-organization similarly to how the logical elements make up a carrier of Boolean algebra. The first part of article is devoted to the review of earlier published results, which prove that, if both the frames of reference and the viewed objects are of undular nature, then the existence of a carrier of the waves does not contradict to relativity theory and Maxwell equations. In the last section the mechanism of spherical wave stability is discussed. It is shown, on the basis of this mechanism it is possible to explain the existence of the complex long-range ordered structures.**

Index Terms — **Wave model, stable wave, long-range ordered structures, quantification, self-organization.**

I. INTRODUCTION

The development of the modern electronics is related to diminution of components sizes. This is the essence of nanotechnologies. In this process is very important that the development of fundamental physics did not lag behind needs of practice. It is necessary to mark, that over the physicist of semiconductors is still dominated by the tendency to consider the fundamental particles as point objects, and as model of atoms Bohr model is used.

However miniaturization of components till the sizes in nanometers any more does not allow ignoring undular properties of the mater. At the same time, the quantum mechanics considering undular properties of mater does not possess a sufficient transparence to be the high-grade tool, suitable for use by researchers-experts. Moreover, many authorities recognized in this field express the opinion, that the quantum mechanics should not to try be understood at a rational level, there is enough that it allows to describe the physical phenomena. Such position frightens off the developers-experts. The undular model offered in the monograph [1] allows understanding clear up the mechanisms of the physical phenomena which are featured with a quantum mechanics and will allow a quantum mechanics to become the high-grade working tool.

Let's remind the essence of undular model:

1. All physical phenomena occur in the world continuum.
2. The world continuum is considered as a continuous medium, which properties (pressure, density, velocity of displacement) are described by analytical functions. I.e. functions, practically continuous and differentiable necessary number of times. More exact definition of analytical function can be found in [2].
3. As all the physical phenomena are in essence fluctuations in a world continuum, the tools by means of which observation is yielded, also it is necessary to view as fluctuation of a world continuum.
4. In a world continuum there can be fluctuations of parameters. The functions describing these fluctuations can be decomposed in a series on potential functions (Fourier series or integral), depending from coordinates and time.

The specified potential functions represent waves and are described by functions of a view.

$$a = A\cos(-kx)\cos(\omega t). \tag{1}$$

In the article [3] it has been shown that in an undular frame, the velocity c of traveling wave does not depend on the choice of frame. Hence, the velocity of traveling wave cannot be used for the definition of a velocity relative to the carrier medium, and all undular reference frames are equivalent.

Thus, use of undular frames leads us naturally to statements which serve as postulates for a special theory of relativity. The applications of the undular analysis for description of mechanisms of electromagnetic and gravitational fields are given in the monograph [1]. Some data on this theme are published also on a site [4].

The consecutive application of undular model has allowed finding out, how some wave-tool representing a surplus or a deficit of a continuum, will interact with drops in pressure and velocity in the medium. It turned out that the redundant quantity of a continuum in a wave-tool can be associated with an electrical charge, the pressure gradient - with an electric intensity, and the magnetic intensity – with the drop in velocity. It is shown, that the magnetic field is an effect of the relativistic contraction of the continuum from the point of view of a moving wave-tool. The proofs of these statements are not trivial; they can be found also on my site [4]. The relation between electric intensity **E** and magnetic intensity **B** is determined by Maxwell equations. The deduction of Maxwell equations, proceeding from the offered model, is also given in monograph [1]. It is necessary to emphasize, that Maxwell equations define the correlation between a pressure gradient and a drop in velocity of the medium, and not between pressure and velocity of medium as in the equations of acoustics.

II. INTERACTIONS FROM POINT OF WIEW OF UNDULAR MODEL

As in formula (1) we did not impose any requirements on the amplitude, the obtained deductions will be valid for any amplitude, including the case when the amplitude is some function of spatial coordinates and time. It is known, the wave equation in spherical coordinates for a central-symmetric wave have a view:

$$\frac{\partial^2(rp)}{\partial r^2} - \frac{1}{c^2}\frac{\partial^2(rp)}{\partial t^2} = 0 \qquad (2)$$

The solution without peculiarities of this equation is the harmonic, waves with the amplitude of pressure in the center - p_A which can be described by expression:

$$p = p_A e^{i(-\omega t \pm kr)}, \qquad (3)$$

where the upper sign "plus" corresponds to the wave moving along the *r*, and the lower sign "minus" corresponds to a wave moving in the opposite direction. This solution coincides with the formula of the associated waves, which describe in quantum mechanics a free moving particle:

$$\psi(r,t) = Ce^{i(-\omega t \pm kr)}. \qquad (4)$$

The explanations regarding the physical sense of a wave function and the amplitude can be found in any textbook on quantum mechanics and we will not go deeper into this topic. We will refer only to the quantum-classical correspondence principle [5, 6], according to which the physical phenomena in quantum mechanics are described by equations similar to classical mechanics with the only difference that classical parameters are exchanged with those of quantum mechanics. We will apply this principle in "to the contrary" manner. We consider a fundamental particle-wave (say, an electron) to be described by the sum of two traveling waves in continuum. These waves are harmonic and central-symmetric:

$$p = p_A \frac{e^{i(-\omega t \pm kr)}}{r}, \qquad (5)$$

where the upper "plus" sign corresponds to a divergent wave, and lower "minus" sign – to a converging wave.

In case of the central symmetric wave the distinguished frame is the system bounded to the center of wave. The wave (22) can be rewritten in the trigonometric form:

$$p_S = \frac{p_A}{kr}\sin kr \sin \omega t, \qquad (6)$$

where p_A is the amplitude of pressure in the center of the spherical wave. The diagram of function (23) at $\sin\omega t$=1 is presented on fig. 1. As was marked above, this solution is unique among those, which do not have peculiarities at *r*= 0, while the oscillatory velocity is continuous and becomes zero in the center.

The amplitude p_A/kr in the expression (6) defines the energy of a spherical wave, the factor $\sin kr$ defines a spatial distribution, and $\sin\omega t$ - the time dependence, while $\omega/k = c$. It means, that the expression (6) rigidly relates the energy of a spherical wave with its frequency. Any attempt to change one of these parameters leads to divergence (fig. 2).

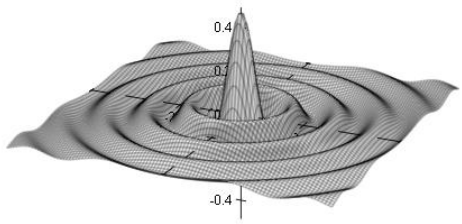

Fig. 1 The graph of function (6) in two-dimensional representation

This property of the function (6) is a key to the quantification riddle. According (6), the argument of sin and the denominator should be similar and such similarity should be absolute. Namely this circumstance provides the rigid bond between energy and frequency in the quantum mechanics. The smallest difference conducts to divergence of the function p_S, i.e. tends to infinity.

By the way, this phenomenon is observed in technology as the *cavitation* phenomenon which destroys the screws of a ship. It is wrongly deemed, that cavitation is caused by bubbles formed due to a rupture of the medium, i.e. the consequence is taken as the cause [7, 8].

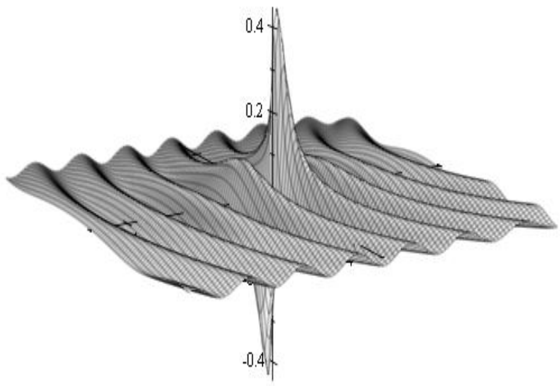

Fig.2. The diagram of function (6) at attempt to upset the balance between frequency and energy of a wave

The spherical waves described by function (6) can be compared to operational amplifiers [9] by means of which physical processes in analog computers [10] are modeled. The basic property of the operational amplifier is that if to disconnect a negative feedback, its amplification factor on voltage (voltage gain) tends to infinity. This ensures that the schemes on operational amplifiers are very stable. Similarly, at disturbance of a relation between amplitude and a phase in expression (6), the amplitude tends to infinity. For infinite amplitude the infinite energy is required but that is impossible. Therefore the structures consisting from spherical waves of an aspect (6) must be very stable. Namely this property of stagnant spherical waves causes the mechanism of quantization in the nature. We shall analyze this idea in more detail.

If two such stable spherical waves interact, the correlation between the argument of *sin* and factor p_A / kr are broken. The divergence is eliminated, if the interacting spherical waves reorganize so, that in their own frames of reference the correlation between the amplitude and the frequency is recovered.

If with such reorganization a part of energy is radiated in the form of a traveling wave the resultant system becomes stable. For destroying such a system it is necessary the energy radiated at its formation to be returned. Thus, two spherical stable waves can form a stable system which, getting into a field of the third wave, or in a field formed by a collective state of several particles, can form a more complex stable state, and so on.

Examples of a combination of two wave objects with same phases and opposite phases are given in figures 3 and 4.

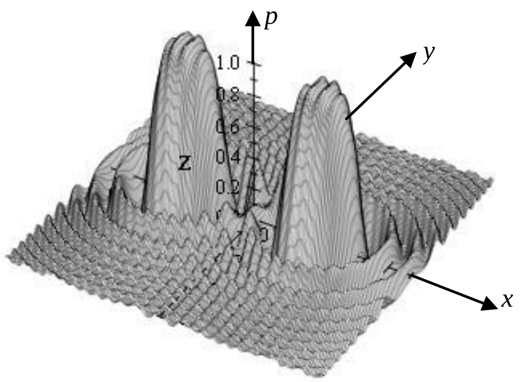

Fig.3. Example of a combination of two wave objects with same phase.

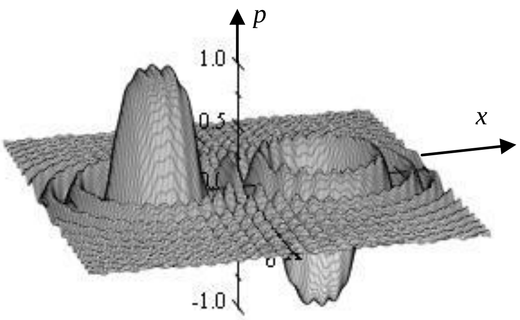

Fig.4. Example of a combination of two wave objects with opposite phases.

The structure presented on figure 3, will be less stable, than the structure presented on fig. 4. The explanation is that in the second case the continuum flows from one spherical wave in another, thus, there is as though a compensation of waves. It means that energy of system will be less, than the summary energy of waves-particles- taken separately.

The image presented in figure 3 we can compare in particular with situation in condensed matter physics, where a Cooper pair from two electrons (or other fermions) are bound together at low temperatures in a certain manner. Effect was first described in 1956 by American physicist Leon Cooper. Cooper showed that an arbitrarily small attraction between electrons in a metal can cause a paired state of electrons to have a lower energy than the Fermi energy, which implies that the pair is bound [11].

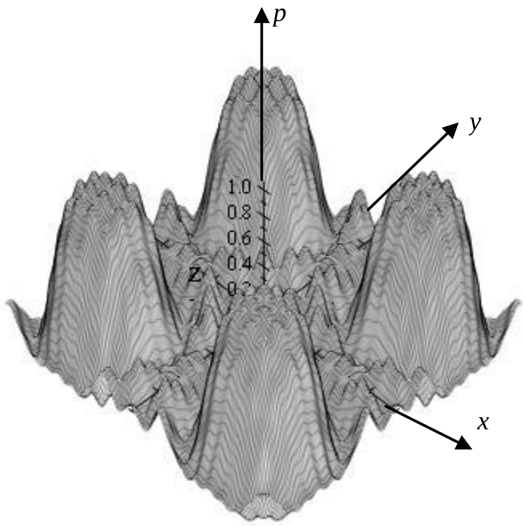

Fig.5. Example of a combination of four wave objects with same phase.

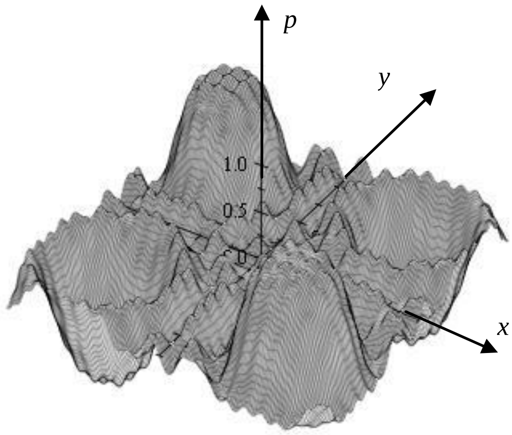

Fig.6. Example of a combination of four wave objects with by pairs opposite phases.

We come to the conclusion that, the stable spherical waves form a set from which can be formed other stable states which also belong to set of stable waves. Out of these new states, other stable states which belong to the same set can form and so on, ad infinitum.

The formulation above brings us to the idea that the waves can serve as elements of a carrier of a universal algebra. A universal algebra A = (*A*, *O*) is an ordered pair, where *A* is a set termed *carrier* of the algebra, and *O* is a set of operations of various *arity* (or, *rank*) over *A* with respect to which the operations is said to be "closed". Thus, the concept of *universal algebra* allows constructing a "closed world" of unlimited complexity. Within the context of this research, the term 'closed' means, that to build up a world of arbitrary complexity it is enough to proceed from elements of a chosen set, and this is the set of waves, which make up the set of generators of a universal algebra.

Similarity of the expressions (3) and (4) allows us to identify the fundamental particles with monochrome stable spherical waves in a continuum described by these expressions. It is known, that as a result of particles interaction, oscillatory systems are formed, which have spectrums of higher complexity. Even the atom of hydrogen consisting of three particles, i.e. proton, neutron and electron, already has a rather complex spectrum. The Plank constant serves as a coefficient in the relationship between energy and frequency. It is important to mention, that in the interaction of stable standing waves not only the amplitudes and frequency play a role, but also their phase, and this leads to indeterminacy of the relation.

It is necessary to remark, that in the formation of complex wave systems there exists a certain energy hierarchy: for creating or destroying complex wave systems, it is necessary less energy. The spectrums of simple oscillatory systems, atoms and molecules, are well studied. The offered algebraic approach is of interest at examination of the complex oscillatory systems in which the binding energy becomes comparable with the energy of fluctuations caused by thermal processes. The combination of stability of wave systems and fluctuations is a key to understanding of self-developing systems, in particular, lying in the basis of life.

There is one more important circumstance related to wave systems, namely that the waves, basically outreach to the infinity. This means, that the wave systems can interact between themselves remotely, defining the structure of each other. This creates the probability of the reproduction (replication) of the wave systems in result of such actions. In my opinion, it is exactly this process which bears the key in the emergence of biological objects.

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