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Update of the crystal world

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Abstract

This work presents some evidences and probable consequences of introduction of discrete medium – the "Crystal World". The "Crystal World" can be considered as a carrier for the fields of a matter. The given medium is believed can be considered as a set of harmonic oscillators filling all space. Discrete medium is introduced on an image and similarity of a crystalline lattice of a condensed matter. The particles - excitation are concentrated in space of a "reciprocal lattice " of "Crystal World". This leads to the violation of the energy and momentum conservation laws at the wave number of particles higher then the wave number of the reciprocal lattice. Some possible confirmation of the given consideration may be the behavior of cosmic rays at energies higher than GZK-limit. The other possible consequences of the "Crystal World" approach in physics of elementary particles, cosmology, and quantum mechanics are also discussed.

INTRODUCTION

The triumph of Einstein's theory of relativity has allowed expelling from physics the unobservable ether. For the time it there was a courageous and justified step. However recently on a wave of rough development of physics of elementary particles and, in particular, such its part as the theory of calibration fields, on our sight, it is ever more reasons to assume the existence of some structure of vacuum, namely:

- The instantons is the evidence that the vacuum state of quantum mechanics has the periodical structure like as the crystalline structure of solid state (see for example[1])
- The violation of C, P, CP and T –invariance evidences about the existence of local geometrical structure of vacuum state of quantum mechanics.
- The constant speed of the light in vacuum, the Lorenz's relations, the existence of charges seems to be very strange properties without the carrier or parent medium like as the crystalline lattice of solid state where the solitons exists, which has the topological charge, Lorenz invariance, and relativistic invariance.
- The existence of fractional charges in quantum field and solid-state physics (see for example[2,3]) is the evidence of long-range analogy between quantum field and solid state.
- The "mixing angles" of quarks, Weinberg's angle, chiral invariance, and other geometrical characteristics of quantum field.

In reality the structure of "Crystal World" radically differs from the classical ether. However, it seems, the logic of development of physics is those, that becomes ripe necessity to give the mentioned above structure some particular properties.

It is possible, that a first step in the given direction could be the introduction of the "discrete carrier" for calibration fields, which in a context of the consideration pointing here seems to be more convenient to rename the material fields.

In order to prevent the misunderstanding under the "Crystal World" here is meant the existence of some medium consisting of discrete oscillators, filling all space and ordered in a "crystalline lattice ". It is simple to see that the introduced carrier represents the analog of a crystalline lattice of solid state. Omitting the problems concerning a nature of "atoms" - oscillators of such discrete carrier and forces connecting these "atoms" in a "crystalline" structure, it would be necessary to concentrate on

possible consequences of introduction of such discrete carrier in a quantum mechanics, physics of elementary particles and, partly, in a cosmology.

It would be necessary at once to note, that the introduction of such discrete carrier will not cause to the drama consequences of a type of a "ether wind " or collisions of material bodies with "atoms" of medium, as in the given approach the material world consists of elementary particles being the excitations of entered "Crystal World".

ROLE OF RECIPROCAL SPACE IN THE STRUCTURE OF CRYSTAL WORLD

One of the strangest properties of a quantum mechanics is the coherence of particles that is the connection of quantum objects among themselves, not dependent from a distance (on this property the well-known paradox of Einstein- Podolsky - Rosen is based). Such connection implies the presence of whole in the each part. It calls association with the hologram. Under the laser beam illumination of a part of the hologram an image of all object embodied in the hologram arises. Such behavior in the radical differs from a photo: at illumination of a part of a photo the appropriate part is visible only.

It is represented, that the specified features are explained to that the quantum objects - particles are the excitations of some discrete medium similarly to phonons in a solid state. If such point of view has the right on existence, it is possible to try to use the full analogy between a field theory and crystalline condensed matter to construct the "Crystal World".

It is necessary to note first, that in connection with the given analogy - the existence of two spaces must be allowed, namely the direct, where the crystalline lattice of a solid state (and, signifies, by the analogy, the hypothetical discrete medium of a field theory e.g. the "Crystal World") exist, and the oscillations of its atoms happens and reciprocal (conjugated or impulse) space, in which the energy and momentum of excitations of discrete lattice - "phonons" are concentrated.

If $G = hA + kB + lC$ - is the vector of a reciprocal lattice of solid state, and $\rho = ma + nb + pc$ - is the vector of a direct lattice, than as is known,

$$\mathbf{G\cdot\rho = 2\pi\, n,} \qquad \mathbf{(1)}$$

where n - is integer. Hence,

$$\mathbf{\exp(iG\cdot\rho) = 1.} \qquad \mathbf{(2)}$$

At the description of wave processes the wave vector k enters in all expressions in a combination of $exp(-ik\cdot\rho)$ and each time, when k will increase by the vector of a reciprocal lattice G, the exponent (2) tend to be unit, since, by virtue of (1)

$$\mathbf{(k + G)\cdot\rho = k\cdot\rho + 2\pi\, n.} \qquad \mathbf{(3)}$$

Therefore we have

$$\mathbf{\exp(-i\,(k\cdot\rho + 2\pi\, n)) = \exp(-ik\cdot\rho).} \qquad \mathbf{(4)}$$

Hence, the wave vectors of a lattice k and $k + G$ are equivalent. By the analogy it is possible to assume the existence of vector of a reciprocal lattice of "Crystal World" discrete lattice G_s:

$$\mathbf{|G_s| = 2\pi/a_s,} \qquad \mathbf{(5)}$$

where a_s - is the size of an elementary cell of "Crystal World" discrete lattice. $|G_s|$ is the wave number, at which the violation of an energy and momentum conservation law in a system of excitations of Crystal World discrete lattice happens. Under aproaching of wave number of a particle to the value of $|G_s|$ its momentum varies with a jump from $h\,(k + G)$ up to hk, where h is the Planck's constant.

COSMOLOGY OF THE CRYSTAL WORLD

Comparing constructed above hypothetical "Crystal World" on a discrete lattice with reality, it is possible to notice some similarity. The intensity of cosmic rays which main part consist of protons, sharply falls down approaching to an upper bound of energy $E_b \sim 10^{21}\ eV$[4,5] far above the well-known GZK –limit[6]. It is possible; that such behavior of cosmic rays can be explained by discontinuous change of the momentum in the vicinity of an upper energy bound E_b. In this case the maximal transferred momentum is equal, under the supposition, to momentum of the reciprocal lattice

$$\mathbf{h|G_s| = ((E_b)^2/c^2-(m_p)^2c^2)^{1/2} \sim 10^{-9}\ J\ sec/m,} \qquad \mathbf{(6)}$$

where c- is the speed of light, m_p – is the mass of a proton. From the expression (6) the value of $a_s = 2.3"10^{-25}\ m$ can be obtained. Below we shall return to the quantity of a_s and we shall try to estimate it from the other reasons.

It is usual, when speak about electromagnetic waves in vacuum, one make an emphasis on the absence of their dispersions. However, it is necessary to notice, that the acoustic branches of lattice modes at small wave vectors also has no the dispersion. In region of wave vectors of the order $h|G_s|$, as it is possible to see from an abovementioned example with cosmic rays, the material fields can have the same dispersion, as sound waves in the condensed matter.

Continuing the analogy with the lattice modes, it is interesting to note that the optical branches of lattice modes have the dispersion even at zero wave vectors. As is well known, the dispersion in nonlinear medium sometimes allows constructing the solitons - the particle-like solitary waves possessing a topological (collective) charge[7,8]. In a field theory the charge also is treated as topological[9] and it would be necessary to think, that this fact also is the indication, that the given considerations have some repre-

sentation in a reality.

As in the hypothetical Crystal World constructed above all objects "are made" from the excitations of discrete medium there is some objective to consider the "observer" watching an events in the "Crystal World", also is constructed from the excitations - particles. Therefore he must not to see the motions of "atoms" of the discrete medium, to collide with them, to feel the "ether wind" etc. As the energy and momentum (and, hence, the mass, the "weight", the hardness, the "materiality") of the excitations are concentrated in the reciprocal space, than the "observers" must exist also in the reciprocal space. The reciprocal space is not such a bad place. As it is shown above the reciprocal space has the peculiar metric. The unit of measure there is served with the reverse meter m^{-1}. The sizes of this space are rather great. If the evaluation of the size of a cell of discrete medium is correct, the dimension of the "first Brillouin's zone» is about $\sim 10^{25} m^{-1}$. It is comparable to the modern horizon of the actual Universe. Thus, the whole actual Universe may well fit in the small "piece" of the hypothetical "Crystal World". Carrying out this analogy further, it is interesting to notice, that when the light wave, reaches the boundary of a reciprocal cell, it is reflected and then it is gone back during $\sim 10^{15}$ *sec.*

Apart from the "compactness" the hypothetical "Crystal World" has the number of other features. So, for example, the cosmology decides a problem of homogeneity of the Universe. To reach this aim the "inflation" scenario is attracted. The hypothetical "Crystal World" has the very high homogeneity. You can see that whole hypothetical universe is actually located in one cell of the discrete medium.

Besides the items pointing above the expansion of the hypothetical "Crystal World" can be treated as the compression of the discrete medium (since at compression the dimension of a reciprocal cell grows). As the material reason of the expansion of our hypothetical Crystal World the heating of the discrete medium would be possible to explain in terms of absorption of the energy from reciprocal space. This hypothetical process could happen similarly to an establishment of thermal equilibrium of the phonon gas in a crystalline lattice of a condensed matter, where the so-called flip-over processes play the basic role:

$$\mathbf{k_1 + k_2 = k_3 + G}, \quad (7)$$

where k_1, k_2 - are the wave vectors of two interacting phonons, k_3 - is the wave vector of the formed phonon. As can be seen from the expression (7), part of energy of interacting phonons is transferred to a crystalline lattice itself. Thus all directional flows (waves) of disturbances in the phonon gas are damped fast due to the "friction" in a crystalline lattice, i.e. the absorption of a part of the energy in each act of scattering. The circumstances specified above give rise to cooling of the reciprocal space and heating of the lattice and create an irreversibility (one-directivity) of processes in the phonon gas.

By the analogy it would be possible to assume, that the similar processes of a flip-over in the discrete medium are the reason of cooling of the hypothetical "Crystal World" and irreversibility of its processes.

QUANTUM MECHANICS OF THE CRYSTAL WORLD

The quantum mechanics of the hypothetical "Crystal World" has been described early[10]. The Hamiltonian of discrete medium by the analogy with the phonon Hamiltonian in a crystalline lattice can be written as follows[11]:

$$\mathbf{H = ?\Sigma(p^2(k,j) + \omega^2(k,j)q^2(k,j))}, \quad (8)$$

where $q(k, j)$ - are the generalized coordinates, and $p(k, j)$ - are the generalized momentum of excitations of the discrete medium. In the conventional quantum mechanics ∂ and q can obtain any values (limited by an indeterminacy principle), i.e. they are independent variables. In a crystalline lattice ∂ and q are linearly connected to the displacement of "atoms" of medium:

$$\mathbf{U_{l\alpha} = \xi(l\alpha;kj)p(kj)}, \quad (9)$$

The indexes l, α designate displacement of l- "atom" in one of the three basis directions α, the index j designates one of three branches of oscillations (for a monatomic lattice) or the polarization of normal modes. The functions of ξ chosen so that to exclude cross terms of the displacement in different points of direct space in expression for potential energy:

$$\mathbf{\xi^*(l\alpha;kj)\xi(l_1\ \alpha_1;kj) = K\delta(ll)\delta(\alpha\alpha)}, \quad (10)$$

$$\mathbf{\xi^*(l\alpha;kj)\xi(l\alpha;k_1\ j_1) = K\delta(kk)\delta(jj)}. \quad (11)$$

The expression (8) represents a sum of arguments relating to the one point of the reciprocal space. This sum has a kind of full energy of non-interacting objects – the "phonons". The essential difference from conventional quantum mechanics is that the generalized coordinate q and momentum p are the functionals of the displacement U, as it is seen from the expressions of (9). Therefore the one of the terms of a sum (8) is possible to rewrite as:

$$\mathbf{H_p = ?(pp^* + \omega^2 qq^*)}. \quad (12)$$

Let's assume, that the displacement of «atoms» represents a flat wave:

$$\mathbf{U = U_0 exp(-i(\omega t - k\cdot r))}. \quad (13)$$

Then for a generalized coordinate and momentum and values, conjugated to them we can obtain:

$$\mathbf{q = U_0 exp(-i(\omega t - k\cdot r))},\ \mathbf{p = \partial q/\partial t = -i\omega q},$$

$$\mathbf{p^* = \omega q},\ \mathbf{q^* = -p/\omega}. \quad (14)$$

Substituting the appropriate values in the expression (12), we obtain:

$$H_p = ?\omega(pq-qp). \quad (15)$$

In the expression (15) in brackets there was a permutation relation for a generalized coordinate and momentum. As the Hamiltonian (15) represents the energy of separate "phonon", it is possible to write:

$$?h\omega = ?\omega(pq-qp) \quad (16)$$

In a left-hand part of the relation (16) there is a value of energy of a ground state of a harmonic oscillator[8]. Whence for a permutation relation we can obtain the well-known expression of quantum mechanics:

$$pq-qp = h. \quad (17)$$

As the expression (16) represents the energy of a harmonic oscillator, we can equate it to the energy of a classical oscillator:

$$?h\omega = ?m\omega^2a^2, \quad (18)$$

Where m - is the mass, ω - is the oscillation frequency of "atoms" of discrete medium. The frequency of oscillations of a harmonic oscillator is equal:

$$\omega = \sqrt{k/m}, \quad (19)$$

Where k - is the elastic modulus. Talking about the discrete medium i.e. the medium "completed" with the harmonic oscillators, it should bear in mind that this medium sustains the oscilation waves (the analog of "sound" in the condensed mater) with the speed:

$$\nu_s = a\sqrt{k/m}. \quad (20)$$

Finally for a Planck's constant we can obtain:

$$h = mca. \quad (21)$$

In the last expression the speed of "sound" is replaced by speed of light c.

Looking at the expression (13) for a flat wave of displacement of "atoms" of the discrete medium it is possible to notice, that this relation within a factor coincides with the expression for a wave function of free motion:

$$\Psi(r,t) = \exp(-i(wt-k\cdot r)), \quad (22)$$

being the solution of a temporary Schrodinger equations. In this connection introduction of a wave function in a quantum mechanics is represented excessive, and the Schrodinger equations simply are not necessary, as the displacement $U_{l\alpha}$ are determined by a set of the equations of motion of a Newton-type for "atoms" of the discrete medium by the analogy to a crystalline lattice of a solid state. Making this kind of reasoning, we find that the "quanta" are completely determined by the "lattice" of a discrete medium, the commutation relations (and the uncertainty relations) follow directly from the energy conservation law, the wave function and "probability density" are the artificial constructs.

In this regard some remark about gravity and "quantum gravity" should be made. Introduction of vacuum lattice as a skeleton of space is favorable for such kind constructions as entropy gravity[12]. The benefit of Crystal World is the existence of natural bits of lattice cells fovoring to introduction of entropic force without of holographic principle of[12]. This kind of scenario requires the energy exchange between direct and reciprocal spaces which is possible only at energies (6) corresponding to violation of energy conservation law. This may be an explanation of distinction of gravity on the Galactic level. As for the "quantum gravity" this term is inapprorpiate in the frame of discussed scheme because entropy approach excludes the quantization of gravity as it is not considered as a fundamental interraction. This gives rise to assumption about non-wave nature of gravity and impossibility to find the gravitation wave. This may be supported by such simple reasoning about the black hole. If the gravitation wave exists then it's energy has a weight. Therefore such wave cannot leave the black hole due to its gravity. But we can detect the black hole by its gravity. So the gravity has a non-wave nature.

In summary, we have shown that the Crystal World approach can explaines the existence of such basic properties of vacuum of actual Universe as a constant speed of light, the Lorenz's relations, the existence of charges, C, P, CP and T –invariance, and other geometrical characteristics.

The key role in the Crystal World plays the reciprocal space where the collective excitation of ground crystalline lattice are located. All material objects (and people including) of actual Universe consists of such excitation. This is the reason of absence of the "ether wind" in our world. Also the existence of reciprocal space gives rise to violation of energy and momentum conservation laws which however can be revealed at very high energies only.

The flip-over processes which are well-known in solid state can explain the cooling (due to friction in the crystalline lattice) and the irreversibility (one-directivity) of all processes in the Universe.

The misterious relations of quantum mechanics and the Planck's constant are easily deduced under the assumption that there exist the flat wave of displacements of "atoms" of crystalline media.

The space skeleton introduced by the vacuum lattice is favorable for the entropy theories of gravity which gives rise to prediction about non-wave nature of gravity.

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