Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 102 (2018) 101-115 EISSN 2392-2192

To the synthesis of classical and quantum physic

V. A. Etkin

Institute of Integrative Investigations, Haifa, Israel

E-mail address: v_a_etkin@bezeqint.net

ABSTRACT

The possibility has been validated to adjust fundamental differences between classical mechanics and quantum mechanics from the position of the wave theory of matter structure. A derivation of the Planck radiation law has been offered proceeding from the assumption the wave is a true quantum of radiation. The principles of photoeffect have been explained from the positions of classical phisycs and supplemented with consideration of the photoelectric yield. The law of forming spectral series has been obtained with no involvement of quantum numbers and no assumption of electron orbit-to-orbit transition. A deterministic derivation of the Schrödinger stationary wave equation has been given as excluding the necessity of its probability interpretation. The possibility has been shown to construct in unified manner mechanics of macro- and microprocesses considering discretness of wave processes.

***Keywords*:** quantum machanics, nonequilibrium thermodynamics, radiation laws, quantums of light, Schrödinger equation, spectral series, photoeffect, wave as quantum

1. INTRODUCTION

Up to late XIX century classical mechanics reached a high level of development. Major difficulties occurred only in its application to phenomena in the microcosm. Those were mainly connected with the laws of thermal radiation from objects, the problem of atom planetary model stability and the inconsistency of ether properties [1]. Nevertheless, those difficulties by no means signified a near quantum-relativistic revolution since were construed

(Received 03 June 2018; Accepted 20 June 2018; Date of Publication 21 June 2018)

at those times as mere 'clouds on the sky of classical physics' [2]. Therefore many researchers have up to date asked the question how far inevitable those revolution had been. A special topicality these issues have gained with the advent of that 'comprehension crisis zone' [3] which theoretical physics is now going through. It has become more preferable 'to guess equations with no attention to physical models or physical explanation for some phenomenon or other' [4]. Scientists have stopped being oppressed by the fact that their theories do not elucidate the reality any more. They do not already put the problem of comprehending the cause-and effect relationships in manifestations of some laws or others. An explanation of phenomena has stopped being the major function of science. These conditions have resulted in effective 'theories of everything' appeared promising the possibility to move backwards in time, to use the energy of zero fluctuation of vacuum, to instantaneously move in space, to transit to 'parallel world', to convert the Universe into 'singularity', etc. These theories fire imagination and are rich with sensations. However, they are senseless to expect a payoff from them since the subjects of their fantasy are far beyond the current possibilities of their detection and, all the more, use.

Looking back to the historical past one can hardly avoid the conclusion that it is the abundance of new experimental data that put the scientists under the time pressure conditions when they lost the possibility to permanently correct the classical concepts. In this context the question repeatedly arises that Academisian S.I. Vavilov first raised, viz. 'does classical physics appear really to be impotent as compared with the quantum laws of light action?' [5].

2. INCONSISTENCY OF QUANTUM CONCEPT IN PLANCK'S INTERPRETATION

In October 1900 M. Planck received the newest data of F. Kurlbaum and G. Rubens regarding the energy distribution in the blackbody spectrum. For several days he found, in his words, a 'good interpolation formula' complying with both the Wien law (1893) and Rayleigh law (1900) and in the same month reported it to the German Physics Foundation [6]. The focus of the Planck's attention at that time was on the expression for second-order derivative of radiation entropy with respect to radiation energy $\partial^2 S/\partial^2$. In the short-wave range (wherein the Wien law works) this derivative was inversely proportional to first-order energy, whereas in the long-wave range – to the second-order energy. M. Planck constructed a compromise option – $\partial^2 S/\partial^2 = a/U(U + b)$ providing their simplest generalization. In this case he, following Boltzmann, did not reject the possibility to ascribe temperature T and entropy S to radiation despite the ordered character of the oscillatory motion and rather cautious attitude of Boltzmann and his contemporaries toward entropy.

Later on, to theoretically justify his law, Planck had to resort to even more revolutionary postulate of energy quantization for oscillators. For Planck, being keen on music, it was natural that an oscillator can vibrate on frequencies multiple of integer quantities (harmonics). In such a case it seemed to be natural that the energy of each oscillation mode ε_n/n would be proportional to the oscillation frequency ν, i.e. $\varepsilon_n = nh\nu$, where h is some proportionality factor. However, it by no means followed from here that the said factor was independent of oscillation amplitude A_ν and frequency ν and, moreover, that the said factor was unified for oscillators of any nature. Meanwhile, it was what Planck had to hypothesize. According to his postulate the imaginary oscillators in the blackbody cavity can be present in only discrete states with energies $\varepsilon_n = nh\nu$, where $n = 1,2, \ldots, \infty$ are positive integer quantities named 'quantums' later on. Here the oscillators can release or receive energy by only integral portions (quantums) $\varepsilon_\nu = h\nu$.

M. Planck stated that the spectral radiant intensity $u_\nu = dE_л/d\nu$ may be expressed as product of the statistically average energy of oscillator $\langle\varepsilon_n\rangle$ and the number of the oscillators $n_\nu = dN_\nu/d\nu = 8\pi\nu^2/c^3$ radiating within the frequency band $d\nu$, i.e. $u_\nu = \langle\varepsilon_n\rangle n_\nu$. Then, after Rayligh, the radiation energy in the unit volume cavity $E_л$ may be expressed as integral of u_ν within the entire frequency band $0<\nu<\infty$:

$$E_л = \int u_\nu \, d\nu = \int \langle\varepsilon_n\rangle dN_\nu \text{ , J m}^{-3}. \quad (1)$$

However, to avoid the 'violet catastrophe' due to the unlimited rise of the radiation energy $E_л$ with the frequency ν, M. Planck, unlike J. Rayligh, postulates that the number n_ν of the oscillators radiating within the frequency band $d\nu$ exponentially decreases with frequency rise though obeying the Boltzmann statistics:

$$N_\nu/N = \exp(-nh\nu/kT), \quad (2)$$

where: k is a quantity Planck named as 'Boltzmann constant'.

In such a case the statistically average value $\langle\varepsilon_n\rangle$ for quantum of energy ε_ν of any frequency can be found by series expansion of (2) in n with further approximation of this series as:

$$\langle\varepsilon_n\rangle = h\nu/[\exp(h\nu/kT) - 1], \text{ J}. \quad (3)$$

Considering (3) expression (1) takes the form $E_л = \int u_\nu \, d\nu = \int (8\pi\nu^2/c^3)\langle\varepsilon_n\rangle d\nu$, wherefrom follows the required law of radiation spectral density distribution:

$$u_\nu = (8\pi h\nu^3/c^3)/[\exp(h\nu/kT) - 1], \text{ J s m}^{-3}. \quad (4)$$

This distribution is distinct from the Rayligh law

$$u_\nu = (8\pi\nu^2/c^3)kT \quad (5)$$

in that here, instead of the kT value, a more complex expression (3) for the average energy of oscillator takes place.

Though the radiation law (4) perfectly discribes experimental results, the Planck's contemporaries discovered a number of inconsistencies in its validation. One of them objected to the hypothesis of quantums since it disagreed with the concepts of not only mechanics, but entire classical physics. Others were confused with obscure physical meaning of the h value with its action dimension, which de Broglie named as a 'misterious constant'. Still others noted the Planck's inconsistency when at series expansion $\exp(-nh\nu/kT)$ in n the ν frequency assumed being invariable. In such a case, as known from mathematics, the frequency distribution is continuous, too, even if n is dicrete. Besides, to find the radiation energy spectral density u_ν, it is unnecessary to know the distribution over ν. Still others paid attention to the fact that the radiation density $E_л$ (J m^{-3}) does not yet define the radiated power W m^{-3} which depends on the number ν of the quantums radiated per unit time. Still others pointed out the restriction in the quantum numbers *n*, while the exp(-*nh*ν/*kT*) in *n* assumed their infinity. Such rebukes yet at Planck's time were stored in plenty. M. Planck himself up to the end of his life considered the thermal radiation problem unsolved and persisted in his attempts to improve the validation of his law [7].

Later more serious shortcomings of that law became apparent. In particular, A. Einstein discovered that on a wavelength of 0.5 mm at T = 1700 K the quantum energy was 6.5 10^7 times above the energy of the oscillator itself [7]. In addition, the independence of the emission quantum εν from the oscillation amplitude contradicted the expression for the wave energy density ρ_ν known from the theory of oscillations [8]:

$$\rho_\nu = \rho A_\nu^2 \nu^2/2, \ (\text{J/m}^3), \tag{6}$$

according to which the energy density for minor oscillations of elastic medium with density ρ at frequency ν is proportional to their squared amplitude A_ν.

Not less serious inconsistencies were revealed at analysis of the Planck law from the positions of energodynamics [10]. In particular, Planck considered the quantum energy ε_o as a ramp function of frequency ν. As a matter of fact, it decreases with frequency. This directly follows from the sense of the ε_ν value as a derivative of oscillator energy density (6) with respect to N_ν:

$$\varepsilon_\nu = (d\rho_\nu/dN_\nu) = \rho A_\nu c^3/8\pi\nu = h_\nu/\nu, \ \text{J}, \tag{7}$$

where: $h_\nu = \varepsilon_\nu \nu = \rho A_\nu^2 c^3/8\pi$ (W) is a value depending on only the distribution of amplitudes of oscillators N_ν, i.e being a kind of a 'spectral constant'.

As follows from (6), the decrease of the quantum energy is dictated by more rapid increase of the number of oscillators N_ν with ν rising, but not their decrease as supposed per (2). This fact reveals inconsistency of the Boltzmann's statistics as applied for solution to the 'violet catastrophe' problem. Indeed, the Planck's postulate as itself initially implies a decrease of that portion of the oscillator energy $\varepsilon_n = nh\nu$ that the oscillator releases in one emission event. This portion is defined as $\varepsilon_\nu/\varepsilon_n = 1/n$ and decreases with *n* increasing. Hence, expression (2) actually characterizes the distribution of the oscillator energy ε_n over *n* and characterizes the average value of this portion for any value of the energy quantum $\varepsilon_\nu = h\nu$. In other words, the distribution (2) includes the connivance that averaging over $\varepsilon_\nu/\varepsilon_n$ is equivalent to averaging over N_ν/N. In such a case (2) should be written as:

$$\varepsilon_\nu = \langle\varepsilon_n\rangle \exp(-\varepsilon_n/kT) = h\nu/[\exp(h\nu/kT) - 1]. \tag{8}$$

This relationship means a decrease of the quantum energy *h*ν with frequency ν increasing in defiance of the Planck's postulate which is, thus, incompatible with (8). Nevertheless, only in this case the energy quantum ε_ν can be inferior to $\langle\varepsilon_\nu\rangle$ as Planck postulates. Moreover, only in this case substituting (8) in (1) gives the Planck law (4). At the same time it means that the *h* value is to be averaged, too.

Additional "inconsistencies" were revealed in the analysis of expression (3) by the method of "address" (subjective) dimension, requiring the indication of the subject to which this or that quantity belongs) [11].

In this case, the incorrectness of the physical model of the equilibrium radiation becomes obvious, since the exponential sign is a dimensional quantity. Indeed, the energy quantum $h\nu$ refers to the oscillator in the cavity of the ACT (the subject dimension J/osilator), and the energy kT - to the atoms of the radiator (subject dimension J/atom).

Thus, the validation of the radiation law by Planck is fraught with serious inconsistencies. The same about the initial concept of Planck and his forerunners regarding the thermal equilibrium existing between radiation and radiating body, since the equilibrium in thermodynamics is characterized by ceased energy exchange, whereas the latter is known to be going on even at T =0. All this taken together induces to searching another validation of the Planck radiation law – more adequate with the up-to-date concepts of radiation.

3. ENERGODYNAMIC VALIDATION OF THE PLANCK RADIATION LAW

Equilibrium thermodynamics is obviously insufficient to analize the processes accompanying radiation. Since the temperature of stars differs many orders from the temperature of the interstellar medium and the star spectrum is discrete, the radiant heat exchange between them by no means can be considered as equilibrium and thermal. Nonequilibrium thermodynamics was necessary for this as considered the kinetics of real (nonstatic) processes. However, the theory of irreversible processes (TIP) was developed only by mid-XXth century - and that only with application to relaxation phenomena [13, 14]. It became quite adequate and solvable only after its generalization to nonthermal forms of energy and to processes of a useful (reversible) transformation of energy [10].

The fundamental feature of the energodynamic approach to the radiation problem is the consideration of the radiation as not substance, but as irreversible process whereby the internal energy of radiator U converts into an ordered flow of radiant energy J_r which is transferred in the interstellar medium and converted back into internal energy of the radiation receiver. With such an approach not temperature T and entropy S become the radiation parameters, but the energy carrier flows $\mathbf{J}_\nu$ and their motive forces $\mathbf{X}_\nu$. They are introduced in energodynamics based on (6). To do so, the time t total derivative of the wave energy density $d\rho_\nu/dt$ is represented as sum of local $(\partial\rho_\nu/\partial t)$ and convective $(\boldsymbol{c}\cdot\nabla)\rho_\nu$ component. The latter is broken down here into factors $\mathbf{J}_\nu$ and $\mathbf{X}_\nu$ in the same way as adopted in thermodynamics of stationary processes [22, 23]:

$$(\boldsymbol{c}\cdot\nabla)\rho_\nu = \rho A_\nu\nu\, \boldsymbol{c}_g\cdot\nabla(A_в\nu) = -\,\mathbf{J}_\nu\, \mathbf{X}_\nu\ , \ (\mathrm{W\ m^{-3}}), \tag{9}$$

where: $\mathbf{J}_\nu = \rho A_\nu\nu\mathbf{c}$ is a value known as spectral density of radiation (J m^{-3}); $\mathbf{c}$ is the speed of propagation of disturbances in the light-bearing medium, taken numerically equal to the speed of light in a vacuum c; $\mathbf{X}_\nu = -\nabla(A_в\nu)$ is the thermodynamic force expressed by negative gradient of wave potential $\psi_\nu = A_\nu\nu$ (m/s) [10].

Owing to the relation $\mathbf{J}_\nu = \mathbf{J}_\nu(\mathbf{X}_\nu)$ existing and named transfer equation, radiation obeys the same regularities as the processes of thermal conductivity, electric conductivity, diffusion, etc. According to this, the power radiated by a body of unit volume is expressed as the integral $J_r = \int \rho_\nu d\nu$ of the radiation spectral density $\rho_\nu = dJ_r/d\nu$. Since each of N_ν oscillators radiates ν waves with energy ε and the number of oscillators within the frequency band $d\nu$ is equal to $dN_\nu = (8\pi\nu^2/c^3)d\nu$, the density of radiant energy flow $J_л$ (power radiancy of radiator) is defined as:

$$J_r = \int \rho_\nu d\nu = \int \varepsilon_\nu dN_\nu = (8\pi/c^3)\int \varepsilon_\nu \nu^3 d\nu \text{ , W m}^{-3}. \tag{10}$$

Thus, to find J_r, it is necessary to average ε_ν not over the amplitudes A_ν of the oscillators N_ν with the same frequency ν, but over the frequency ν, too. This task is not beyond the classical Gibbsian statistics. In this case the function exp($-\varepsilon_\nu/kT$) does not demand any more to be expanded into series, since the Gibbs distribution allows it should be reduced to the integral

$$\int_0^\infty e^x dx = e^x - 1 \tag{11}$$

by substituting $x = \varepsilon_\nu/kT$. In such a case ε_ν will be expressed through medium-integral value of the wave energy $\bar{\varepsilon}_\nu$ in the form of the relation similar to (8):

$$\varepsilon_\nu = \bar{\varepsilon}_\nu/[\exp(\varepsilon_\nu/kT) - 1], \tag{12}$$

Substituting (12) in (10) we can get the radiation law as:

$$\rho_\nu = (8\pi\nu^2\bar{\varepsilon}_\nu/c^3)/[\exp(\varepsilon_\nu/kT) - 1], \text{ J m}^{-3}. \tag{12}$$

The Planck law, thus modified, differs from its original (4) in that it involves, instead of the constant h with the action dimension (J s), the averaged value of the disturbance $\bar{\varepsilon}_\nu \nu$ (W) being bintroduced by the single oscillator into the luminiferous medium per unit time. The role of quantum is here played by the single wave discrete both in time and space. In this case the wave energy $\bar{\varepsilon}_\nu$ as radiation quantum appears to be much smaller, since it appears to be ν^2 times inferior to the energy quantum $h\nu$ by Planck. This eliminates the problem of SHF photon energy redundancy noted by A. Einstein. This also eliminates the disagreement with the wave theory, since in this case the density of the wave energy ρ_ν remains proportiona to the squared frequency.

Thus, besides the dimension with its clear physical sense the radiation law (12) differs from the Planck law in the absence of whatever disagreements with classical physics. It is also fundamentally important that the proposed derivation of the radiation law (12) is not based on irrealistic physical models such as a radiating cavity with ideally reflecting walls and absolute blackbody properties. This conclusion did not postulate an increase in the energy quantum with frequency and did not require thermal equilibrium between matter and radiation. He did not anticipate the equality of the vibration amplitude of the structural elements of matter and did not claim that only electrons emit in atoms. All these restrictions being elemenated means that the radiation law found is unified for both absolute blackbodies and grey and 'colored' bodies, both stationary and nonstationary radiation processes, both equilibrium and nonequilibrium radiation. In all these cases different may appear the quantum $\bar{\varepsilon}_\nu$ value and the position of power radiancy maximum due to deviation of radiator properties from absolute blackbody. This fact grants to the law offered a more general status of universal law not depending on the luminiferous medium nature and radiation process 'mechanism'. In this case the quantum nature of radiation is not any more in conflict with the classical concepts of energy continuity in the absence of oscillation process[1)].

However, it should be noted that understanding of all facts associated with the above conclusion is substantially facilitated if based on the wave theory of matter structure [15]. According to this theory 'there are waves and only waves existing in the nature: closed waves we call matter and open waves we call radiation or light [16]. This view was shared by E. Schrödinger who considered up to the end of his life that 'what we presently regard as particles are actually waves' [17]. The positions of the wave theory of matter structure substantially strengthened after discovery of solitons as solitary, staructurally stable and particle-like waves [18]. It was revealed later that this notion might be generalized to also standing single waves in the media free of viscosity, when structural stability is achieved also in the absence of velocity dispersion and energy dissipation. This allowed considering baryonic matter as a structured part of the Universe matter consisting of soliton-like 'waves-particles' [15]. Such waves are power dipoles holding them at a certain distance multiple of the wavelength. Stability of such wave structures is ensured also in the absence of various-nature forces and their oscillations are what generates radiation. For such structural formations the de Broglie's idea about the wave-particle dualism looks quite natural. An explanation is also gained for some mere 'quantum' effects such as multislot diffraction.

One more important consequence – the radiation quantum gets a simple and clear sense of the wave as unit disturbance of luminiferous medium whatever physical model of this medium we adhere to. All this refutes the popular belief about impotence of classical physics as compared with the quantum law of light action and inspires hope for organic synthsis of classical and quantum physics.

To justify these hopes, let us consider some of the phenomena which are regarded explainable from the positions of the quantum theory of light only.

4. CLASSICAL EXPLANATION OF PHOTOEFFECT

In 1887 German physicist H. Hertz in experiments on radiation of electromagnetic waves with discharger (a couple of metal balls placed into vacuumized glass chamber) discovered a growth of discharge appeared under the action of voltage $\Delta\varphi$ applied to the balls if one of them was lighted up with ultraviolet rays. Thus the external photoeffect was discovered [19].

The first studies of the photoeffect conducted by A. Stoletov (1888) revealed the following regularities [20]:

1) Maximum kinetic energy of the photoelectrons rises as ramp function of light frequency and does not depend on incident light flux $J_л'$;

[1)] Never jumps to mind the idea to consider ocean as consisting of drops only because such is the process of its replenishment with rainfall.

2) The number of the electrons being torn out from the metal surface per second (photocurrent I) is directly proportional to the light flux $J_л^{'}$;
3) If the light frequency is inferior to some minimum frequency ν_o ('shortwave limit') certain for this particular matter, the photoeffect does not occur. In this case the value of the 'cut-off potential' (the voltage $\Delta\varphi_o$ blocking emittance of photoelectrons) rises as ramp function of the radiation frequency ν and does not depend on the radiation rate $J_л^{'}$. For alkali metals this 'photoemission threshold' lies within the visible light range.

The said regularities were confirmed by subsequent studies by Lenard (1900), Richardson and Compton (1912), as well as Millikan (1916). Theoretical explanation of this feature from quantum positions gave A. Einstein (1905) [21], for which he was awarded in 1921 the Nobel Prize. He expressed the energy balance for photoeffect as:

$$E^k = h\nu - W^e, \tag{13}$$

where E^k is kinetic energy of photoelectron; $h\nu$ is energy of the radiation quantum named later as photon; W^e is electronic work function (atom ionization energy). In such a case according to (13) photoeffect does not appear if the photon energy $h\nu < W^e$, i.e. is insufficient for ionization of atom (to do the work function). Further, according to (13) the photon frequency ν being increased, their energy and, hence, also the kinetic energy E^k of the emitted photons is increased as a ramp function, which causes increase of the cut-off potential.

Meanwhile, the simplest analysis of this equation by the method of 'address' (subjective) dimensionality [11] reveals its incompleteness. Indeed, the terms E^k and W^e in (13) relate to one electron (address dimension J/electron), whereas the term $h\nu$ – to one photon (dimension J/photon). It follows therefrom that in the photoeffect equation (13) the term $h\nu$ should contain the devider Y_e with a dimension of (electron/photon):

$$E^k = h\nu Y_e^{-1} - W^e. \tag{14}$$

The value Y_e is known as 'quantum yield' and is the number of the electrons emitted (photocurrent $I_л$) related to the number of the radiation quantums absorbed (radiant energy flux $J_л$). It depends on not only the photon energy, but also on the properties of the photocathode, state of its surface, temperature, etc., reaching to some of the photocathodes a magnitude of ~10^{-4} order. This means that such photocathodes need up to 10^{-4} photons to 'knock out' one electron. This fact is considered when choosing photocathodes in terms of value of the so-called 'spectral sensitivity' $\partial E^k/\partial\nu$. However, this fact conflicts with the concept the (13) is based on and natural for particles that one photon always interacts with only one electron. As a result, the (13) does not consider the multi-photon emission phenomenon and fails to explane existing spectral sensitivity of photocathodes since the derivative $\partial E^k/\partial\nu$ is constant therein:

$$\partial E^k/\partial\nu = h = \text{const}. \tag{15}$$

This means that the quantum explanation of photoeffect A. Einstein offered is incomplete. Meanwhile, from the positions of quantum mechanics it is vitally important that the quantum yield Y_e should always remain less than unity since 'to knock out' electron as a particle, a bombardment with the whole number of photons is needed. The more surprising appeared the results of recent experiments wherein the contrary was revealed [22]. Using a new laser on free electrons and X-raying the xenon atoms with a wavelength of 13 nm and a power of 1015 W cm^2 a group of researchers from Hamburg discovered that photons are able to 'knock out' from gas atoms not one, but the great number of electrons. This was beyond anybody's comprehension of photon as a particle since the latter cannot possibly be absorbed with many electrons simultaneously. Thus, also the external photoeffect earlier construed as the best confirmation of the quantum hypothesis appears now to be conflicting with quantum mechanics.

It is more important then to show that the photoeffect laws may be easily explaned from the positions of the wave radiation theory wherein the frequency ν is considered as a flow of waves absorbed per unit of time by one the $N_ν$ resonant electrons of photodiode. With such an approach the radiant energy flux $J_л$ absorbed by all $N_ν$ resonant electrons of photodiode of unit volume is equal to $\bar{\varepsilon}_ν\ ν\ N_ν$ (W m^{-3}), which the generates the photocurrent I (C m^{-3} s^{-1}). In such a case the photocathode energy balance takes the form:

$$E^k = \bar{\varepsilon}_ν ν N_ν / I - W^e. \tag{16}$$

It follows therefrom directly that the external photocurrent I appears only when $\bar{\varepsilon}_ν\ νN_ν/I \geq W^e$, which proves existing the 'shortwave limit' of external photoeffect (Stoletov's third law). Even more obvious is the fact that the photocurrent I is proportional to the light flux $J_л = \bar{\varepsilon}_ν νN_ν$ (Stoletov's second law). Finally, since the ratio $\bar{\varepsilon}_ν νN_ν/I$ will define the 'cut-off voltage' $Δφ_o$, it also follows from the (16) its ramping increase with the rising frequency ν at constant current I (Stoletov's first law).

Thus, all the laws of photoeffect may be obtained with no resort to postulates of quantum character. Moreover, the wave nature of radiation facilitates understanding also other specific features of photoeffect, in particular, its high response showing itself in no lag in time between occurrence of light flux and photocurrent. It is explained by the fact that the photocathode being at stationary state does not accumulate energy, but releases it right away for the half-period following the absorbtion of the radiation. In this case only the amount of the energy received will dictate the way of this occurrence – either by emission of electrons or by conventional reradiation. It is even easier to explain the selective character of photoeffect showing itself in the abrupt rise of photocurrent at resonant frequencies. It is not a difficult task to explain also the nonlinearity of photoeffect being expressed in its dependence of the light intensity and the radiation angle, since it it what defines the radiant energy flux $J_л$. absorbed.

It is characteristic that the explanation offered did not need whatever resort to specific 'quantum' postulates including the concepts regarding the discreteness of energy levels of oscillators in the blackbody cavity and electrons in atom, also regarding the indivisibility of photon as a particle and proportionality of its energy to frequency, the instant (no duration) process of electron interorbital 'jump', the photon 'masslessness', etc. In this case the fact of discreteness of the light flux as a flow of soliton-like waves by no means impeded using the laws of classical physics. This inspires hope for possible return of physics into the fold of classicism.

5. CLASSICAL VALIDATION OF SPECTRAL SERIES

In 1885 Swiss scientist J. Balmer compiled an empirical formula describing all known at that time spectral lines of hydrogen atom and then offered a generalized formula as:

$$\nu = R(1/m^2 - 1/n^2), \tag{17}$$

where: $R = 1.1{\cdot}10^7$ m^{-1} is a constant named after him; m are integers defining the name (number) of the spectral series (Lyman, Balmer, Paschen, etc.); $n = m + 1$, $m + 2$ etc. – some integers.

The attempts to think up mechanical models of oscillators characterizing this regularity failed. From the positions of the atom planetary model with electrons rotating around nucleus it seemed impossible the existence of electron stable orbits as such due to the so-called centripetal acceleration[2)] existing and reaching a values of 10^{22} m s^{-2}.

This inseparably involves the problem of existing atom as itself due to seemingly inevitable fall of the electron onto the nucleus, as well as occurring in this case a continuous spectrum of radiation in defiance of experiment. It also seemed inexplicable the spectral lines available for one-electron atom, as well as the strict determinateness of its therms, multiplets, series combinations, etc.

Therefore, up to the present it has been considered that only the quantum theory of atom structure could explain the above regularities. Meanwhile, the regularities of spectral series formation can be validated with no using ideas of quantum-mechanical character and this can be done in the most simple way from the wave theory of atom structure. The very core of the subject is as follows below. According to energodynamics [10] forces of any nature $\mathbf{F}_i$ occurring are caused by nonuniform distribution of material carrier Θ_i (mass M, charge $З$, momentum $\mathbf{P}$, etc.) in space, i.e. by energy gradient of the corresponding form of energy U_i:

$$\mathbf{F}_i \equiv - (\partial U_i/\partial \mathbf{r}), \text{ H.} \tag{18}$$

Not an exeption are the gravity forces $\mathbf{F}_g = - \mathbf{F}_i$ which are caused by nonuniform distribution of the Universe interstellar matter density of interstellar matter in the space of the Universe. These gravitational forces lead to an increase in density inhomogeneities in the non-baryonic component of interstellar space and to the subsequent fusion of regions of increased density into the "nuclei" of baryonic matter of various hierarchical levels, from atoms to galaxies. Under conditions of isotropy of the properties of space, these nuclei must have a shape close to spherical.

The thus formed spherical standing waves can have a very different period of oscillation - from billions of years to ultra-high frequencies. Any wave has a semiperide in which its amplitude Aν (and accordingly the energy U_i and its gradient) either increase or decrease. Therefore, the sign of the sign of the arising force in expression (18) on the leading and trailing edges of the wave is different. However, in the antinodes of any waves there is no attraction or repulsion force ($\mathbf{F}_i = - (\partial U_g/\partial \mathbf{r}) = 0$).

[2)] It was unknown at that time the absence of such an acceleration at uniform rotation and the more general definition of any forces $\mathbf{F}$ as derivatives of energy U of the system with respect to radius vector of its energy carrier center (here: of kinetic energy $E^к$ wrt radius vector of center of inertia $\mathbf{R}_\omega$)

This also determines the stability of the structure formed of several concentric "shells" around a stable core. This is, according to the latest data, the structure of atoms, which behave as if they consist of concentric zones (bands) of elasticity [23].

If we adhere to such a "shell" model of atoms, it becomes clear why in the above experiments the "elasticity" belts were spaced apart from each other at a multiple of the de Broglie wavelength [23]. The reason is that the distances between adjacent antinodes of standing waves are proportional to the real wavelength, i.e. $r_n = n\lambda$ and $r_m = m\lambda$, where $n = 2$ or more is the oscillating shell closest to the nucleus; $m = n + 1$, $n + 2$ - numbers of subsequent shells. Thus, regardless of the nature of the atomic forces (which can be either Newtonian or Coulomb), the distance between the antinodes of standing waves and the core is a multiple of the wavelength. Since these forces are inversely proportional to the square of the distance r_m^2 or r_n^2 to the nodes of the standing waves, the difference of the central forces acting on the side of the nucleus to the first and subsequent shells $\Delta\mathbf{F} = \mathbf{F}_n - \mathbf{F}_m$ ($r_m > r_n$) will be proportional to the expression].

$$\Delta\mathbf{F} \propto (1/r_n^2 - 1/r_m^2), \qquad (20)$$

and the relative value of $\mathbf{F}_m/\mathbf{F}_n$ is given by:

$$\mathbf{F}_m/\mathbf{F}_n = (1 - n^2/m^2). \qquad (21)$$

On the basis of expression (9), $\mathbf{F}_m/\mathbf{F}_n$ can be replaced by the ratio of the thermodynamic forces $\mathbf{X}_\nu = -\nabla(A_в\nu)$, expressed by the negative gradient of the wave potential $\psi_\nu = A_\nu\nu$. If we denote by A_n, ν_n and A_m, ν_m the amplitude and frequency of oscillations of the shells n and m, then instead of (21) we can write $\mathbf{F}_m/\mathbf{F}_n = \nabla(A_m\nu_m)/\nabla(A_n\nu_n)$, that for the same degree of amplification or attenuation of oscillations in neighboring shells (at $\nabla A_m/\nabla A_n = 1$) leads to the expression for the spectral series in the form:

$$\nu_m = \nu_n (1 - n^2/m^2). \qquad (22)$$

Expression (22) corresponds to the relationship (17) Balmer found. According to (22) radiation freaquencies are discrete and, with n increasing, reduce to their upper limit ν_n. In this case n_n, as before, dictates the series name: Lyman ($n_n = 1$), Balmer ($n_n = 2$), Paschen ($n_n = 3$), Brackett ($n_n = 4$), Pfund ($n_n = 5$), etc.

In the semi-classical N. Bohr's model these values were construed as some 'quantum numbers' of which the angular momentum of the electron rotating around the nucleus is multiple. The capability of this momentum to adopt only discrete values also by no means ensued from classical mechanics and was a one more postulate absolutely obscure for the conditions when external oscillating medium was absent. This postulate even more enhanced the intrinsic inconsistency of the quantum theory of radiation. This inconsistency, in particular, showed itself in the fact that the rotation of electrons around the nucleus at stationary states was assumed as following the laws of conventional mechanics, whereas the transition of atom from one stationary state to another was assumed as 'instant' (no duration). Now instead of them appear quite specific values - the number of the oscillating ("radiating") shell in the wave model of the electron. Actually, this is exactly what is meant in quantum physics, which replaces the orbit in the planetary model of the Rutherford atom with an orbit as a sort of "blurred" electron cloud.

Conspicuous is also the simplicity enabling a number of the regularities observed to be explained from the said positions. In particular, it is quite natural that the electrons occupying the shells nearest to the nucleus are more subjected to influence of the gravity forces and are, therefore, less mobile. In the Rutherford-Bohr's model of atom it is associated with the nearest to nucleus and, therefore, more 'stable' orbits, in quantum mechanics – the first 'orbital' sensibly close to the 'electron shell' of atom. The wave theory also explains why, with the potential energy of electron increasing, the frequency of radiation rise for any spectral series.

The justification for the law of the formation of spectral series proposed here complements this previously applied to the model of the Rutherford - Bohr atom [10]. Thus, the law of the formation of spectral series can be justified for both models of the atom without using considerations of a quantum-mechanical nature and the abstract concept of quantum numbers

.

6. DERIVATION OF SCHRÖDINGER STATIONARY EQUATION

The Schrödinger equation considered as underived from whatever classical principles crowns quantum mechanics. It is usually regarded as a result of its author's genius intuition. In quantum mechanics the Schrödinger equation is considered as one of postulates like the Newton's laws are the postulates of classical mechanics.

This equation is known to be based on the de Broglie's hypothesis of 'wave-particle' dualism [5] declaring that each kind of atoms is associated with certain radiation and absorption wavelengths. This idea that the wave properties are inherent in all substances corresponded to the vision of Schrödinger himself who adhered to the wave concept of matter structure all his life. However, the validation he offered himself has not been always quite convincing for researchers. The simplest analysis by the 'address' dimensionality method evidences that this statement makes sense. Really, Schrödinger assumed after de Broglie that each particle (e.g., electron with mass m_e and energy $\varepsilon_e = h\nu$) is associated with the wavelength $\lambda = h/p_e$, where $p_e = m_e c$ is electron momentum. Meanwhile, in the expression $\lambda = h/p_e$ the left-hand side refers to wave (photon) and the right-hand side – to oscillator (electron). Thus, the physical model of phenomenon, the dualism concept is based on, fails to be validated.

Everything is OK if considered that electron is a wave, too, only localized in space and able to excite in luminiferous medium running waves but of another, nonelectromagnetic nature. Then it becomes evident that both in the shell model and planetary model of atom the radiation is associated with an oscillation process in atoms. This oscillation process is most frequently described by the equation of spatial monochromatic wave [9]:

$$\nabla^2\psi + k^2\psi = 0, \tag{23}$$

where: ψ is any oscillating value (density of the medium, force field intensity, etc.); $k = 2\pi/\lambda$ is the wave vector.

Let us now express the squared wave vector in terms of the wave energy density ρ_ν (6):

$$k^2 = (8\pi^2/\rho A_v{}^2 c^2)\rho_v \tag{24}$$

The value ρ_v is the wave kinetic energy in the unit volume system, which is a difference between its total energy (Humiltonian function) H and potential energy U^p related to also unit volume. Therefore, instead of (23) we can write:

$$\nabla^2\psi + (8\pi^2/\rho A_v{}^2 c^2)(H - U^п)\psi = 0 \tag{25}$$

This expression formally differs from the the Schrödinger stationary equation in only that instead of the multiplier $8\pi^2 m_e/h^2$ for the electron with mass m_e the value $8\pi^2/\rho A_v{}^2 c^2$ is involved therein not containing the Planck constant h. However, there are substantial differencies in the interpretation of the wave function. From the positions of the wave theory the Schrödinger equation is a conventional 'dynamic' wave equation describing two waves scattering in every direction. In this case the wave function Ψ_e describes any oscillating value, e.g., the wave amplitude A_v distributed randomly in space, or the wave potential $\psi_v = A_v\nu$ (9).

Copenhagen school of physicists interprets this function in absolutely different way. In their interpretation this function is a value whose square being multiplied by the volume element dV describes the probability $\psi^2 dV$ of the particle being in the spatial domain assigned. This notion assumes, on the one hand, indeterminism even at the level of elementary mechanical processes, and on the other hand – the application of the probability notion to individual atom or individual molecule, which is rather senseless, too. As a result, there are no hitherto consensus among the most prominent theoretical physicists in the interpretation of this function.

Meanwhile, it is quite natural that should a disturbance source, e.g., electron, have not only maximum amplitude in its dislocation point, the 'probability of its location', in the Bohr's interpretation, would be maximum, too. Therefore, the wave and probabilistic approaches, as a matter of fact, do not disagree. However, at the wave approach the deterministic nature of the solution to the Schrödinger equation becomes more obvious. This facilitates in eliminating extra indeterminism of quantum mechanics, which would result in its loosing the ability to fulfil the main function of science, viz. to predict and explain phenomena.

Further, from the theory of differential equations it is known that the equations like (23) have countless numbers of solutions, wherefrom those are taken which are physically sensible. Such a selection is conducted by imposing boundary conditions which are construed here as finiteness, unambiguity and continuity of the wave function along with its first derivatives. Among these solutions, there are also discrete solutions if the potential energy U^p is determined on the basis of the virial theorem (R. Clausius, 1870), according to which it is negative and twice the kinetic energy. However, such a definition is in flagrant contradiction with classical thermodynamics, energy dynamics and the theory of relativity, according to which energy is a purely positive quantity. It was this discrepancy in its definition that gave R. Feynman the reason to state that "modern physics does not know what energy is" [4].

Thus, the quantization of energy as a function of the state, and not of the process, is not at all an inevitable consequence of the Schrödinger equation. This is, perhaps, the most acute of the questions connected with quantum mechanics.

7. CONCLUSIONS

1) The centenary period of the existence of the concept of light quanta and their corpuscular nature was insufficient to elucidate the meaning of Planck's "mysterious constant" and justify the interpretation of the radiation process as being devoid of duration. On the contrary, in the system of substantiation of Planck's radiation law based on the hypothesis of quanta, a lot of serious contradictions were discovered.
2) The amount of accumulated knowledge about the radiation process gives sufficient grounds for recognizing the nonequilibrium and nonthermal nature of this process, which requires the revision of Planck's substantiation of his radiation law. The proposed approach from the standpoint of energodynamics allows us to justify this law with allowance for the quadratic dependence of the oscillation energy on its frequency and amplitude without involving any postulates of a quantum mechanical nature.
3) Rethinking the Planck's radiation law leads to the conclusion that the true quantum of radiation is a wave discrete both in time and in space. In this case, Planck's constant in its radiation law appears as a product of the average wave energy at its frequency. At the same time, the energy of the wave decreases with frequency, which removes the problem of the "violet catastrophe" and the excess energy of the microwave quanta.
4) The consideration of radiation from the standpoint of the wave concept of the structure of baryonic matter sheds new light on the nature of the wave-particle dualism and the phenomena associated with it. At the same time, the radiation process appears as an equitable method of energy exchange, obeying the same laws as heat exchange, mass transfer, diffusion, electrical conductivity, and so on.
5) The proposed approach eliminates many contradictions of quantum mechanics, allowing at the same time:
   - to justify the Planck radiation law without resorting to specific postulates of a quantum-mechanical nature;
   - supplement the description of the photoelectric effect by taking into account the spectral sensitivity of the photocathodes;
   - give a new justification for the law of forming spectral series, which does not use the concept of quantum numbers;
   - to obtain the Schrodinger equation as a direct consequence of the wave nature of radiation, which does not require a probabilistic treatment of the wave function
6) Quantum mechanics in its constructive part is actually a branch of physics that studies discrete processes in the microcosm. In this connection, it is advisable to further bring together methodological principles and the conceptual system of classical and quantum physics.

References

[1] Mehra J., Rechenberg H. The Historical Development of Quantum Theory. V. 1. Springer Verlag, 1982.

[2] Tomson W. Collected Papers in Physics and Engineering. Cambridge University Press, 1912. ASIN B0000EFOL8

[3] Popper K.R. Quantum theory and the schism in physics. – London; New York, 1982

[4] Feynman, R. (1964). The Character of Physical Law. Messenger Lectures, 1964.

[5] Vavilov S.I. Experimental foundations of the theory of relativity. Collection of works, vol. 4. - Moscow: Acad. of Sciences USSR , 1956 (in Russian).

[6] Planck M. Über eine Verbesserung der Wienschen Spektralgleichung. *Verh. andl. Dtsch. Phys. Ges.* 1900, 2, 237–245.

[7] Planck, M. Zur Geschichte der Auffindung des physikalischen Wirkungsquantums. *Naturwissenschaften*, 1943, 31 (14–15), 153–159.

[8] Einstein A., Infeld L. Evolution of Physics. Cambridge, 1938.

[9] Crawford F. Waves. Berkeley Physics course. Vol. 3, McGraw-Hill, 1968.

[10] Etkin V. Energodynamics (Thermodynamic Fundamentals of Synergetics).- New York, 2011, 480 p.

[11] Etkin VA. Improving the efficiency of analysis method of dimensions. The Scientific Method, 2017, 4. P. 32-37.

[12] Etkin V. Rethinking Plank's radiation law. *Global Journal of Physics,* 2017, Vol. 5, № 2. P. 547-553.

[13] De Groot S.R., Mazur P. Non-equilibrium Thermodynamics. – Amsterdam, 1962.

[14] Haase R. Thermodynamik der irreversiblen Prozesse. Darmstadt, 1963.

[15] Etkin VA. On Wave Nature of Matter. *World Scientific News* 69, 220-235 (2017).

[16] Jeans J.H. The New Background of Science. — London, 1933.

[17] Schrodinger E. *Ann. Physik*, 1926, 79, 361.

[18] Filippov A.T. Many-sided soliton. - Moscow: Science, 1990, 288 p.(in Russian).

[19] Hertz, H. (1887). On an effect of ultra-violet light upon the electrical discharge. *Annalen der Physik.* 267 (8): S. 983–1000. Bibcode:1887AnP...267..983H

[20] Stoletow, A. (1888). On a kind of electric current produced by ultra-violet rays. *Phil. Mag. Ser.* 5 26(160): 317. DOI:10.1080/14786448808628270.

[21] Einstein A. Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristishen Cesichtspunkt. *Annalen der Physik* 1905, 17(4), 549–560

[22] Richter M. et al. Extreme ultraviolet laser excites atomic giant resonance. *Phys. Rev. Lett.* April 2009.

[23] Demjanov V.V. *Phys. Lett. A* 374, 1110-1112 (2010).