# Rethinking Quantum Mechanics

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***Annotation:*** *The possibility has been shown to obtain the key results of quantum mechanics with no resort to specific postulates based on the thermodynamics of stationary processes. A derivation of the Planck radiation law has been offered to proceed from the assumption the wave is a true quantum of radiation. It has been found that the average energy of such a quantum is numerically equal to the Planck constant. The law of spectral series formation has been obtained without the use of quantum numbers. The photo-effect equation has been supplemented taking into consideration the photoelectric yield. A hypothesis-free derivation of the Schrödinger stationary equation has been given along with its modification as a kinematic first-order equation. The possibility has been shown to consider quantum mechanics as a branch of classical physics studying wave processes.*

***Keywords:*** *quantum mechanics, non-equilibrium thermodynamics, radiation laws, quanta of light, Schrödinger equation, spectral series, photo-effect, wave as quantum.*

## I. Introduction

Classical mechanics that had appeared yet in the XVII century highly developed up to late XIX century. However, the attempts to apply it to the microcosm phenomena caused major difficulties which finally resulted in the quantum-mechanical revolution at the turn of the XIX-XX centuries. Those were mainly connected with the known at that time inadequate laws of thermal radiation from objects and with the behavior of the microcosm objects not in compliance with the laws of classical physics [1].

Quantum mechanics coped with those difficulties with the help of a number of hypotheses and postulates, but gave rise to a lot of new problems and resulted in the 'comprehension crisis' that is now covering theoretical physics totally. By the R. Feynman's figurative expression, it has become more preferable 'to guess equations with no attention to physical models or physical explanation for phenomena' [2]. Scientists do not care about the fact that their theories do not clarify the reality any more. They do not any more put as their target the comprehension of the cause-and-effect relationships in manifestations of laws. An explanation of phenomena has ceased being the major function of science. The style of thinking has taken the character which P. Langevin calls an 'intellectual corruption'.

Under these conditions, spectacular 'theories of all' have grown promising the possibility to move backward in time, use the energy of vacuum zero fluctuations, instantaneously travel in space, transit through 'wormholes' into 'parallel worlds', etc. These theories are full of sensations, however, senseless for practical effect since the subjects of their fantasy are far beyond the current possibilities of their detection and, all the more, their use.

In this context, the question repeatedly arises that Academician S.I. Vavilov first raised, viz. 'does classical physics appear really to be impotent as compared with the quantum laws of light action?' [3]. Attempt to answer this question is the subject of this article. We want to show that the main cause of the difficulties arisen can be identified as the inability of classical thermodynamics to consider kinetics of real radiation processes. However, this cause is absolutely removable from the positions of non-equilibrium thermodynamics.

## II. 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 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 [4]. The focus of the Planck's attention at that time was on the expression for the second-order derivative of oscillator entropy with respect to oscillator energy. In the short-wave range (wherein the Wien law works) this expression has the form of $\partial^2 S/\partial U^2 \propto 1/U$, whereas in the long-wave range $\partial^2 S/\partial U^2 \propto 1/U$. M. Planck constructed the value $\partial^2 S/\partial U^2 = a/U(U + b)$ providing the simplest generalization of both. In this case he, following Boltzmann, ascribed temperature $T$, entropy $S$ and gas constant $R$ to radiation as to a substance. However, a short time later, Planck had to reject that idea and resort to a more revolutionary postulate of energy quantization for oscillators. According to this postulate the oscillator energy $\varepsilon_n = n\varepsilon_o$, i.e. is composed of $n$ equal parts (quanta) $\varepsilon_o = h\nu$ proportional to frequency $\nu$ and, therefore, the oscillator can release or receive energy by only discrete portions multiple of natural numbers $n = 1, 2, \ldots, \infty$. In this case, the proportionality factor $h$ is a universal value depending on neither the nature of the oscillator nor its frequency $\nu$ and amplitude.

Further, to avoid the 'violet catastrophe', M. Planck, unlike J. Rayligh, assumes that the number $N_\nu$ of the oscillators in the blackbody cavity radiating within the frequency band $d\nu$ exponentially decreases to their total number $N_o$ with $n$ increasing thus obeying the Boltzmann statistics:

$$N_\nu/N_o = \exp(-\varepsilon_n/kT), \tag{1}$$

where $k$ is a quantity Planck introduced and named as 'Boltzmann constant'.

In such a case the statistically average value $\langle\varepsilon_n\rangle$ for the quantum of energy $\varepsilon_o = h\nu$ of any frequency can be found by expansion (1) in series of $n$ with a further approximation of this series as:

$$\langle\varepsilon_n\rangle = \varepsilon_o/[\exp(\varepsilon_o/kT) - 1], \text{ J.} \tag{2}$$

Then the radiation energy density $E_r$ can be expressed as integral of product between $\langle\varepsilon_n\rangle$ and the number of oscillators $dN_\nu = (8\pi\nu^2/c^3)d\nu$ contained in the unit volume cavity and oscillating within the frequency band $d\nu$, otherwise as integral of radiation spectral density $u_\nu = dE_r/d\nu$ through the whole frequency band $0<\nu<\infty$:

$$E_r = \int u_\nu d\nu = \int \langle\varepsilon_n\rangle dN_\nu = (8\pi/c^3) \int \langle\varepsilon_n\rangle \nu^2 d\nu, \text{ J m}^{-3}. \tag{3}$$

Considering (2) this gives the radiation law as:

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

It can be easily seen this equation differs from the Rayligh law:

$$u_\nu = (8\pi\nu^2/c^3)kT, \text{ J s m}^{-3} \tag{5}$$

in that here, instead of the $kT$ value, a more complex expression (2) for the average energy of oscillator takes place.

Conspicuous is the dimension of the $u_\nu$ value, which corresponds to the concept of action alien for classical thermodynamics of quasi-static processes. Here comes the dimension of action for the Planck constant $h$ (J s) causing a lot of misinterpretations. However, classical thermodynamics could not offer any other approach since considered the energy $E_r$ as a function of the state entirely.

At the same time the analysis of the Planck law (4) reveals a number of even more serious inconsistencies. Firstly, as per the Planck postulate the quantum energy $\varepsilon_o = h\nu$ increases with

frequency and does not depend on the amplitude of oscillations. These both statements conflict with the expression of the wave energy density known from the theory of oscillations [5]:

$$\rho_v = \rho A_v \, v /2, \text{ (J m )}, \tag{6}$$

according to which $\varepsilon_o$ decreases with frequency rise due to the fact that the number of waves $n_v$ oscillating at this frequency increases more rapidly. One can make sure of this if takes derivative of oscillators energy density $\rho_v$ with respect to the number of the oscillators $dN_v = (8\pi v^2/c^3)dv$:

$$\varepsilon_o = (d\rho_v/dN_v) = \rho A_v^2 c^3 /4\pi v, \text{ J.} \tag{7}$$

Thus, the Planck postulate conflicts with the oscillation theory in not only the statement that $\varepsilon_o$ increases with frequency, but also in the assumption that the factor $h$ is unified for all media and oscillators.

Secondly, A. Einstein showed that at a wavelength of 0.5 microns and $T = 1,700\ K$ the quantum energy $\varepsilon_o$ 6.5 $10^7$ times exceeded the energy of the oscillator itself found from the internal energy of the radiator. This fact not only conflicts with the Planck postulate but also violates the energy balance at photo-effect since can cause an emission of more than one photo-electrons. Thus the Planck postulate gives rise to a more general problem of photon excess power of super-high frequency [6].

Thirdly, as yet Planck's contemporaries noted, at the expansion of $\varepsilon_n$ in series (2) the frequency $v$ assumed to be constant. That by no means corresponded to the problem of 'ultra-violet catastrophe' prevention.

Further, the affirmation that the radiation in the blackbody cavity had the properties of material object featuring a chaotic form of energy and being in thermal balance with that radiation was not supported by any experiments.

Finally, it was known yet in Planck's times that radiation from bodies, unlike heat exchange, never ceased. As known from the heat exchange theory, the equality between the absorbed $J_r'$ and radiated $J_r''$ energy flows meant the stationarity of radiation process, but not the availability of heat balance defined in thermodynamics as termination of whatever macro- processes. That fact made senseless the physical model of 'equilibrium heat radiation' as itself.

Not incidentally, M. Planck himself, to the end of his life, considered the heat radiation problem unsolved and persevered in his attempts to update the validation of his law [7]. It was not his fault that at those times there was no alternative thermodynamics capable to use the concept of energy flow and the heat exchange theory either.

However, this cannot be said about the contemporary physics who continue to talk about an 'equilibrium', 'thermal' and 'blackbody' radiation for colored bodies under a temperature drop of millions of degrees and within a frequency band far outside the heat radiation.

### III. Self-Consistent Justification of Planck's Radiation Law

The principal difference of the proposed approach is the consideration of radiation from the standpoint of the wave concept of radiation and energodynamics, which does not consider it as a certain substance filling the cavity of an absolutely black body (ABB) and being in thermal equilibrium with it, but as a stationary process of radiant energy exchange between it and the environment [11]. With this approach, the body under study becomes the emitter itself, and the frequency $v$ of its oscillations acquires the meaning of the spectral flux of waves $J_v = v$, that is, the number of waves with a length $\lambda$ modulated in the environment per unit time. Each such wave is discrete both in time and in space, which makes its energy $\varepsilon_v$ a true emission quantum [12].

It takes into account that each atom as an oscillator, in addition to the fundamental oscillation frequency $v_o$, has n harmonics corresponding to twice, three times, etc. frequency $vn$

$= n\nu_o$ ($n$ = 1,2,3, etc.). Then the energy $\varepsilon_n$ emitted by one oscillator is the sum of the energies emitted at all its harmonics $n$:

$$\varepsilon_n = \Sigma_n \varepsilon_\nu n \text{ (Дж)}, \tag{9}$$

Assuming that the harmonic energy $\varepsilon_\nu$ is distributed according to the same normal law with respect to the fundamental frequency $\nu_o$

$$\varepsilon_\nu = \varepsilon_{\nu o} \exp(-\varepsilon_n/kT), \tag{10}$$

we find that the averaging method used by M. Planck is quite acceptable for finding the "average harmonic" value of the oscillator energy $\varepsilon\nu ›$. This method leads to an expression similar to (2):

$$‹\varepsilon_\nu› = \varepsilon_\nu/[\exp(\varepsilon_\nu/kT) - 1]. \tag{11}$$

If we substitute this relation in expression (1), we find:

$$E_r = \int u_\nu d\nu = \int‹\varepsilon_\nu›n_\nu d\nu = (8\pi/c^3) \int \varepsilon_\nu \nu^2 [\exp(\varepsilon_\nu/kT) - 1]^{-1} \, d\nu, \text{Дж м}^{-3}, \tag{12}$$

This expression differs from (3) only by the designation of the average oscillator energy $‹\varepsilon\nu›$. From it directly follows the law of radiation:

$$u_\nu = (8\pi\nu^2\varepsilon_\nu/c^3)/[\exp(\varepsilon_\nu/kT) - 1] \text{ (Дж с м}^{-3}) \tag{13}$$

It is easy to see that with the substitution $\varepsilon_\nu = \varepsilon_o = h\nu$, this expression takes the form of Planck's radiation law (4). However, in order to avoid from the very beginning the appearance of the concept $u_\nu$, which is absent in optics, with the dimension of action, we proceed to the description of radiation in terms of the parameters with which nonequilibrium thermodynamics and heat transfer theory operate. Let us define the concept of the surface density of the radiant energy $j_r = u_\nu c$ (J m$^{-2}$) as the product of the energy density $u_\nu$ and the velocity of its transfer in space with. Then the full (integral) flux of radiant energy $J_r$ will have the meaning of the so-called "energy luminosity":

$$J_r = \int j_r d\nu = (8\pi/c^2) \int \varepsilon_\nu \nu^2 [\exp(\varepsilon_\nu/kT) - 1]^{-1} \, d\nu, \text{Вт м}^{-2} \tag{14}$$

In this form, the radiation law has the same dimension as in the Stefan-Boltzmann law $J_r = \sigma_r T^4$ (W m$^{-2}$), which allows us to calculate the value of $\varepsilon_\nu$ without any quantum-mechanical postulates. Indeed, taking into account that $\varepsilon_o = \varepsilon_\nu$ and $\nu = c/\lambda$, in accordance with (9) we can put:

$$\varepsilon_o = \rho A_\nu^2 c^3 /4\pi\nu = h_o\nu, \tag{15}$$

where $h_o = \rho A_\nu^2 \lambda^2 c$ is a certain proportionality coefficient, which remains constant on the basis of the experiments. Then, denoting $\exp(\varepsilon_\nu/kT)$ by $e^x$, where $x = \varepsilon_\nu/kT = h_o\nu/kT$, expression (14) can be reduced to

$$J_r = (8\pi k^4/c^2 h_o^3) \int x^3 (e^x - 1)^{-1} dx. \tag{16}$$

Given that the integral $\int x^3 (e^x - 1)^{-1} dx$ in the interval $0 < x < 1$, corresponding to the range $0 < \nu < \infty$, has an exact value of $15/\pi^2$, and comparing expression (16) with the experimentally known value $\sigma_r = 5,67 \cdot 10^{-8}$ ($W \, m^{-2} \, K^{-4}$) with $k = 1,38 \cdot 10^{-23}$ ($J \, K^{-1}$), we find after Planck that $h$ is numerically equal to its constant $h = 6,626 \, 62 \cdot 10^{-34} \, J \, s$.

This allows us to assert the identity of the distribution of the so-called "energy exposure" (meaning the spectral energy luminosity

$$j_r = (8\pi\varepsilon_\nu\nu^2/c^2)/[\exp(\varepsilon_\nu/kT) - 1], \text{Дж м}^{-2} \tag{17}$$

to the Planck radiation law (4).

It remains to show that the radiation process obeys the same laws as the processes of thermal conductivity, electrical conductivity, diffusion, etc. With this purpose, we represent the total

derivative $d\rho_v/dt$ of the wave energy density (7), as usual, in the form of a local $(\partial\rho_v/\partial t)_\mathbf{r}$ and convective $(\mathbf{c}\cdot\nabla)\rho_v$ component:

$$d\rho_v/dt = (\partial\rho_v/\partial t)_\mathbf{r} + (\mathbf{c}\cdot\nabla)\rho_v = (\partial\rho_v/\partial t)_\mathbf{r} + \rho A_\text{в}v\ \mathbf{c}\ \nabla(A_\text{в}v),\ \text{Вт м}^{-3} \qquad (18)$$

The term $\rho A_\text{в}v\ \mathbf{c}\ \nabla(A_\text{в}v)$ is easy to give the form of the product $\mathbf{j}_r\cdot\mathbf{X}_r$ of the flux of the radiant energy carrier $\mathbf{j}_r = \rho A_\text{в}v\mathbf{c}$ $(J\ m^{-3})$ to the driving force of the radiant energy exchange $\mathbf{X}_r = -\nabla(A_\text{в}v)$, as is customary in the theory of heat-mass exchange, energy dynamics [4] and thermodynamics of irreversible processes [11]. Then the law of radiant energy exchange can be written in one with other transfer processes of the vector form:

$$\mathbf{J}_r = L_r\ \mathbf{X}_r, \qquad (19)$$

where $L_r$ is the so-called phenomenological coefficient, similar to the coefficients of thermal conductivity, electrical conductivity, diffusion, etc.

Such a description of stationary radiation processes emphasizes the inadmissibility of identifying two fundamentally different processes: the oscillatory process in the system corresponding to equation (7) and the local derivative $(\partial\rho_v/\partial t)_\mathbf{r}$, and the process of radiant energy transfer in space (19), the corresponding convective derivative $(\mathbf{c}\cdot\nabla)\rho_v$. Understanding this difference is important not only because it allowed us to obtain the Planck radiation law without using the quantization of the energy postulate. It becomes clear that quantized not the energy of oscillators, which in the steady-state process of interconversion of kinetic and potential energy generally remains constant in time, but the flow of discrete material carriers of radiant energy (be it a photon or a wave with impulse $\mathbf{j}_r = \rho A_\text{в}v\mathbf{c}$). No one would ever think of counting the ocean as a drop of water just because precipitation falls this way!

Thus, we conclude that it is not energy that is quantized as a function of the state of the object, but the process of energy exchange between it and the environment. With this approach, there is no need to resort to other postulates, including the possibility of dividing the energy of oscillators into equal shares, which for unknown reasons are absorbed or emitted only entirely, the assumption of the existence of some imaginary cavity with absolutely mirrored walls, as well as the concept of radiation as something an unknown substance with the properties of an ideal gas that is in thermal equilibrium with it.

In this form, the law of radiation can be obtained without the use of the postulate on the quantization of energy, contrary to all classical physics. In this case, there is no need to resort to other postulates of a quantum-mechanical nature, including the possibility of dividing the energy of oscillators into equal shares, which are also absorbed or radiated only "entirely". Moreover, grounds for recognizing the existence of specific quantum mechanics that does not obey the laws of classical physics disappear.

It is interesting to consider from these positions a number of phenomena that are currently classified as "purely quantum".

## IV. Classical Interpretation of Photo-Effect

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 photo-effect was discovered [13].

The first studies of the photo-effect conducted by A. Stoletov (1888) revealed the following regularities [14]:

1) The maximum kinetic energy of the photoelectrons rises as a ramp function of light frequency and does not depend on incident light flux $J_\text{л}^{'}$;

2) The number of the electrons being torn out from the metal surface per second (photocurrent I) is directly proportional to the light flux $J_r$;

3) If the light frequency is inferior to some minimum frequency $\nu_0$ ('shortwave limit') certain for this particular matter, the photo-effect does not occur. In this case, the value of the cut-off potential' (the voltage $\Delta\varphi_0$ blocking emittance of photoelectrons) rises, as a ramp function of the radiation frequency $\nu$ and does not depend on the radiation rate $J_r$. 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). The wave theory of light failed to satisfactorily explain them at that time, which gave impetus to the quantum-mechanical concepts and philosophy of indeterminism.

It was A. Einstein who, as known, gave a theoretical interpretation of these regularities in 1905. He expressed the energy balance for photo-effect through the energy $h\nu$ of radiation quantum called photon later on:

$$E_k = h\nu - W_e, \tag{20}$$

where $E_k$ is the kinetic energy of photoelectron; $W_e$ is electronic work function (atom ionization energy).

According to (20) photo-effect 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 (20), the photon frequency $\nu$ being increased, their energy and, hence, also the kinetic energy $E_k$ of the photons emitted by photocathode is increased as a ramp function, which causes an increase of the cut-off potential.

Such an interpretation of the photo-effect looked so convincing that the researchers did not pay attention to the incompliance of the dimensions between the terms in (20) if the dimensions consider that the values in (20) belong to a concrete object. We called such a dimensionality 'address' or 'subjective' one [15]. Then it becomes evident that the terms $E_k$ and $W_e$ relate to photoelectrons, i.e. have the subjective dimension J/electron, whereas the term $h\nu$ – J/photon). Thereby it is postulated in (20) that one photon is always sufficient to 'knock out' one electron. Meanwhile, as it became known from the subsequent experiments, the number of the absorbed photons actually relates to the number of emitted electrons in the range of ~0,5 throughout ~$10^4$, which is named as 'quantum yield'. Besides, this relation depends on not only the energy of the photons but also on the properties of the photocathode, condition of its surface, its temperature, etc. The latter is taken into consideration through the value of 'integral' and 'spectral' sensitivity of the photocathode. This fact is not considered in (20) since therein:

$$\partial E^k / \partial \nu = h = \text{const} \tag{21}$$

irrespective of the photocathode nature. This means that the interpretation of the quantum nature A. Einstein offered for photo-effect was incomplete.

The said controversies may be eliminated by introducing the value of the quantum yield $Y_e$ with the 'address' dimension (electron/photon) in the balance equation (20):

$$E^k = h\nu Y_e^{-1} - W^e. \tag{22}$$

The photoelectric yield will thereby be taken into consideration:

$$\partial E^k / \partial \nu = h Y_e^{-1}. \tag{23}$$

As can be seen, the value of the quantum yield $Y_e$ in the equation of the photo-effect energy balance (20) should be necessarily present. However, in such a case the photo-effect regularities can be interpreted without resorting to quantum mechanics (QM).

Indeed, the value $Y_e^{-1}$ means the ratio of the wave flow ν to the flow of the emitted electrons $J_e$ (current).This current is the quotient obtained when the photocurrent $I_e$ is divided by the electron charge $e$. In such a case the expression (20) may be written if the form:

$$E_k = h_o \nu / J_e - W_e. \tag{24}$$

It follows therefrom that the external photo-effect $I_e = eJ_e$ appears only when $h_o \nu / J_e > W^e$, which proves the existence of its 'shortwave limit' (Stoletov third law).

Further, considering that according to (24) $h_o \nu$ is the density of the monochromatic radiation flow $J_r$, (20) may be represented in the form:

$$I_e = eJ_e = (E_k + W_e)J_r. \tag{25}$$

It follows from this expression that, should $E_k$ and $W_e$ be constant, the photocurrent $I_e$ is proportional to the light flux $J_r$ (Stoletov second law).

Finally, it follows from (24) that, to keep the photocurrent $I_e$ from the photocathode, it is necessary to apply the reverse voltage $-\Delta\varphi_o = I_e R_e$, where $R_e$ is the photocathode circuit resistance. Then

$$-\Delta\varphi_o = [h_o \nu (E_k + W_e) - I_e]R_e. \tag{26}$$

In such a case it is easy to see the ramping increase of the 'cut-off' potential $\varphi_o$ with the radiation frequency ν (Stoletov first law). Thus, all the laws of photo-effect may be obtained with no resort to postulates of quantum character.

Moreover, the wave nature of radiation facilitates understanding also other specific features of photo-effect:

(a) its selective (resonant) character showing itself in an abrupt rise of photocurrent at some frequencies;

(b) no lag in time between the occurrence of light flux and photocurrent;

(c) its nonlinear dependence on the light intensity and the radiation angle, etc. It also becomes clear the spread in the values of Planck constant when determined from equation (20) as a derivative $h = (\partial W^e / \partial \nu)$ at $E_k \sim 0$ since its value is exposed to impact from the quantum yield $Y_e$ which is different for different photocathodes.

It is characteristic that the interpretation offered did not appeal to any 'quantum' postulates. In this case the fact of discreteness of the light flux as consisting of waves by no means impeded using the laws of classical physics. This inspires hope for the possible return of physics into the fold of classicism.

## V. Validation of the Law of Spectral Series Formation

In 1885 Swiss scientist J. Balmer compiled an empirical formula describing all known at that time spectral lines of the hydrogen atom. In 1890 J. Rydberg generalized the formula to the case of the hydrogen-like atoms in the form of:

$$\nu = R \left(1/m^2 - 1/n^2\right), \tag{27}$$

where $R=3.29 \cdot 10^{15} \, c^{-1}$ is a constant named after him and calculated rather exactly from the data of hydrogen spectrum; $m = 1,2,3$,etc.; $n = m + 1, m + 2$, etc. are some integers.

The attempts to give some classical interpretation for the discreteness of the spectral lines and find a physical meaning of the values $m$ and $n$ failed. Only in 1913 that law was interpreted by N. Bohr from the quantum-mechanical positions based on the Rutherford planetary model of the atom. The Bohr's theory postulates that the radiation occurs at the moment of the electron 'jump' from one stable circular orbit to another. However, Bohr had to assume that 'jump' being free of duration since otherwise, the length of the radiated photon (quantum of radiation)

appeared to be unacceptably large. Besides, it also appeared that the frequency v of the photon depended on the parameters of both the initial and subjacent orbits. That meant the electron in some fancy way knew the orbit it would 'jump' to. Such an 'interpretation' violated the 'sanctum sanctorum' of classical mechanics and the science in whole, i.e. the cause-and- effect relationship between phenomena and made the notion of 'process' senseless as itself. As a result, an acute conflict developed between the QM idealistic statements and the natural materialistic concepts, which put the brakes on the science in its development.

The result will be other should we acknowledge that, according to the energy conservation law, the radiation or absorption of energy by an atom is possible only in the case its electrons are decelerated or accelerated by non-central (extraneous) forces $F_n$ arising from force fields external for the atom [16]. The deceleration and radiation occur for that half-period of rotation of the electron when it moves toward the external field $\mathbf{F}$, i.e. $\mathbf{F}\,\mathbf{\upsilon}_e < 0$. On the contrary, for the next half-period $\mathbf{F}\,\mathbf{\upsilon}_e > 0$, and the electron acceleration occurs compensating for the loss of energy by atom at the radiation. This is what assures the stability of the electron orbits preventing the electrons from their fall onto the nucleus.

When some extraneous forces $F_n$ are acting on an electron, its trajectory changes, while the conventional radius of the circular orbit $r_o$ the electron had during the action of, e.g., Coulomb forces $F_o = - e^2/r_o^2$ takes the meaning of r corresponding to the new resultant force $F = F_n + F_o$. Thus, the action of the extraneous forces $F_n = F - F_o$ is described in the form:

$$F_n/F_o = (1 - r_o^2/r^2) \tag{28}$$

According to non-equilibrium thermodynamics [9], the force $F_i$ of any nature gives rise to the flow of the corresponding energy carrier $J_i$ proportional to this force. This reflects in the phenomenological laws of thermal conductivity, electrical conductivity, diffusion, etc., which, in the case of single force, have the following form:

$$J_i = L_i F_i \ , \tag{29}$$

where $L_i$ is the corresponding proportionality factor.

In the case of radiation from such a flow $J_i$ is the number of the waves outgoing from the medium surrounding the radiator and absorbed by atom per unit time. Therefore the force ratio $F_n/F_o$ in (28) may be replaced by the frequency ratio $\nu_n/\nu_o$:

$$\nu_n/\nu_o = (1 - r_o^2/r^2) \tag{30}$$

The same follows from the standpoint of the shell model of the atom [12], in which electrons are closed spherical waves oscillating at harmonic frequencies $\nu = n\nu_o$ and grouped in the form of shells around the nucleus. Then the electron shells or orbitals, like their quantum analogs, are located at a certain distance from the nucleus, $r_o = n_o\lambda_o = n_o c/\nu_o$ and $r = n\lambda_o = nc/\nu_o$. In this case, the ratio $r_o^2/r^2$ in (30) or $r_m^2/r_n^2$ can be replaced by the ratio of the squares of the corresponding harmonics $n_m^2/n_n^2$. As a result, we get:

$$\nu_m/\nu_n = (1 - n_m^2/n_n^2) \tag{31}$$

This equation corresponds to (27) wherein $\nu_n$ is expressed through $R/m^2$. The frequencies of the radiation spectrum therein are discrete and, with increasing the number of harmonic, converge to their upper limit $\nu_n$. However, now, instead of hypothetic quantum numbers, the known values are involved characteristic for any oscillatory systems. Further, this clarifies the increase in the number of Lyman ($n_m = 1$), Balmer ($n_m = 2$), Paschen ($n_m = 3$), Brackett ($n_m = 4$), Pfund ($n_m = 5$), etc. spectral series with increasing atomic weight or nuclear charge number $Z_e$. The point is simply that with the "weighting" of the atom, the central forces also increase, as a result of which only the electron orbits farther from the nucleus participate in the radiation. In this case, we did not need the mysterious "quantum numbers" as properties inherent only in the

microworld. The recognition of their reality brought us back to the Middle Ages, where everything incomprehensible was attributed to the properties of weightless "fluids". Meanwhile, it was precisely this that led to the quantum-mechanical revolution [18].

## VI. . Derivation of Schrödinger Stationary Equation

The stationary Schrödinger equation [19]

$$\nabla^2\Psi + (8\pi^2 m/h^2)\,(H - U_p)\Psi = 0 \tag{32}$$

plays in quantum mechanics the same role as the Newton equations of motion in classical mechanics. It describes the motion of quantum objects in the fields of external forces. It differs from the more general nonstationary equation by the absence of the term $ih\,(\partial\Psi/\partial t)$, which aims to reflect the evolution of the wave function $\Psi(\mathbf{r}, t)$. The presence of an imaginary quantity $ih$ in it leads to the fact that the physical meaning could have only the square of the wave function, which followers of the Copenhagen school interpret as the probability density for finding a particle in a given region of space.

Without this term, the Schrödinger equation seems not so mysterious and completely deducible from the ordinary equation of a spatial monochromatic wave [7]

$$\nabla^2\Psi + k^2\Psi = 0, \tag{33}$$

in which the wave function $\Psi(\mathbf{r}, t)$ acquires the meaning of some oscillating quantity, including the amplitudes of the oscillations of the electrons $A_v$, the energy density of the wave $\rho_v$, etc. The unusual nature of the Schrödinger equation, in this case, consists only in that its wave number $k$ expressed in terms of the parameters of electrons as oscillators. Such a view was based on the de Broglie's idea to reflect the wave-particle duality by associating an electron with a wave of length $\lambda = h/p$, where $p = mv$ is the electron momentum. The assignment of wave properties to a particle was so unusual that most researchers still perceive equation (32) as the fruit of the ingenious intuition of its author.

Meanwhile, according to the wave concept of the structure of matter, dualism is expressed in the presence of a wave of "particle-like" properties, and not vice versa [12]. This becomes especially obvious if the oscillating electron is regarded as a soliton. Therefore, the possibility of representing the wave number $k = 2\pi/\lambda$ through the parameters of the electron is beyond doubt. In this case, multiplying and dividing $k^2 = 4\pi^2/h^2$ by the square of the electron pulse $p^2 = E_k/2m$ and replacing $p^2$ on the basis of de Broglie's hypothesis by $\lambda^2/h^2$, we get:

$$k^2 = 4\pi^2/h^2 = (8\pi^2 m E_k/h^2). \tag{34}$$

Since $E_k$ is determined by the difference between the total energy of the electron $H$ (its Hamiltonian) and its potential energy in the field of central forces $U_p$, we directly arrive at the Schrödinger equation (30). Depending on the uniqueness conditions, its solutions can give both continuous and discrete energy values, that is, they do not require its quantization. In this order, the ideas of de Broglie's hypothesis were needed only for the transition from classical parameters to quantum ones. However, in the light of the new law of radiation (17), this could not be done - it was enough to openly switch to the wave concept of the structure of matter, which Schrodinger adhered to. At the same time, one would not have to resort to any hypotheses and postulates, or to conflict with classical physics. Such an approach opens up the possibility of synthesizing classical and quantum (wave) mechanics on a single platform [20] and returning physics to the classical path of development.

## VII. Conclusion

1. The quantum-mechanical revolution at the turn of the of the XIX – XX centuries was caused by the unreadiness of classical thermodynamics to the study of systems with non-static and discrete processes occurring in them. One of these processes was the thermal radiation of bodies, which requires the use of methods of non-equilibrium, rather than classical thermodynamics.

2. The radiation density distribution, similar to Planck's law, can be found without involving any quantum-mechanical postulates, based on the harmonics of the oscillators and the concept of a wave as an object discrete in time and space.

3. The wave concept of the radiation process allows not only to give a classical explanation to all the laws of the photoelectric effect but also to supplement its equation with a consideration of the so-called "quantum yield", which reflects the dependence of the spectral sensitivity of photocathodes on frequency.

4. The laws of the formation of spectral series can be substantiated without the assumption of the existence of timeless "hopping" of electrons from orbit to orbit and other Bohr postulates. In this case, the role of quantum numbers of an unknown physical nature is performed by harmonics characteristic of any oscillatory systems.

5. The stationary Schrödinger equation can be obtained without invoking the de Broglie conjecture as a kind of a second-order ordinary wave equation in which the wave number is expressed in terms of the oscillator parameters. It does not require energy quantization, and any oscillating quantity as a function of spatial coordinates can play the role of the wave function in it.

6. The proposed classical justification of the basic principles of quantum mechanics allows us to overcome the "crisis of misunderstanding connected with it and opens the way to its construction as one of the sections of classical physics in its application to wave processes.

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