Wave Quanta

1. *The fundamental faults of the Bohr theory and of quantum mechanics*

Experiments show that, in proportion as dimensions of natural and artificial objects decrease, the definiteness and exactness of their structure and motion increase. The modern electronic technologies, in particular, confirm this statement. This is the fundamental law of nature, which should be called ***the law of accuracy***. At the same time, this is ***the law of inaccuracy***, if one considers the higher levels of matter-space, where uncertainty and inaccuracy of structures and motion increase. This binary law can be also called ***the law of accuracy-inaccuracy***.

The concepts, which negate the binary law, do not belong to the fundamental scientific theories and can exist only as temporal theoretical fashions. Quantum mechanics, relying on the ideology of quantum chaos, belongs to such theories. The philosophy of uncertainty of quantum mechanics did harm to science in the 20th century. Using such a philosophy, quantum mechanics has adjusted formally (and adjusts as before) doubtful and, often, evidently erroneous concepts to the experiment. We will show the groundlessness of such an approach on concrete examples.

The simplest forms of wave potential-kinetic fields are the plane, cylindrical, and spherical forms, and also their combinations.

The hydrogen atom is a classical example of the binary spherical-cylindrical field. The *spherical* subfield of possible amplitudes of velocities of microobjects at the subatomic level is defined by the formula

$$\upsilon = \frac{\upsilon_s}{kr}, \qquad (1.1)$$

where υ_s is the amplitude of velocity of the spherical field, corresponding to the condition $kr = 1$. With that, $k = 2\pi/\lambda = 1/\lambda\!\!\!^{-}$ is the wave number.

The expression (1.1) is the effect of constancy of the energy flow in the elementary spherical field, which is described by the cylindrical functions of the order $1/2$. However, it is approximately valid also for spherical fields, which are described by the spherical functions of higher orders, under the condition $kr >> 1$. If r_0 is the radius of the first stationary shell and υ_0 is the velocity on it, then, at the constant k, we have the following relations for the radii and velocities of stationary shells:

$$r = r_0 n, \qquad \upsilon = \upsilon_0 / n. \qquad (1.1a)$$

In the elementary spherical field, n is an integer. This is the homogeneous spherical field. The distance between shells, in such a field, is constant and equal to r_0.

In the homogeneous *cylindrical* subfield of the H-atom, the velocity is defined by the formula

$$\upsilon = \upsilon_c / \sqrt{kr}. \qquad (1.2)$$

When k is the constant, we obtain the following relations for the stationary shells:

$$r = r_0 n, \qquad \upsilon = \upsilon_0 / \sqrt{n}. \qquad (1.2a)$$

The formulae (1.2) and (1.2a) are approximately valid also for the heterogeneous cylindrical fields under the condition $kr >> 1$.

The *spherical* subfield induces Kepler's second law

$$\upsilon r = \upsilon_0 r_0 = \upsilon_s / k = const. \qquad (1.3)$$

The *cylindrical* subfield induces Kepler's third law for circular fields, which dominate in the atomic world:

$$\upsilon^2 r = \upsilon_c^2 / k = const. \qquad (1.4)$$

If velocities of the spherical and cylindrical fields turns out to be equal, then,

$$\upsilon_c = \upsilon_s / \sqrt{kr}. \qquad (1.5)$$

According to the equality (1.3), an elementary action of an electron in the spherical field is the constant quantity:

$$m\upsilon r = \hbar = \frac{h}{2\pi} = const. \qquad (1.6)$$

The Bohr basic postulate states that of all possible orbits only those are permitted for which the angular momentum of orbits is quantized in units of $h/2\pi$, i.e., the moment of momentum satisfies the condition:

$$L = m\upsilon r = n\hbar = n\frac{h}{2\pi}. \qquad (1.7)$$

From this postulate, it follows that $\quad r = r_0 n^2 \quad$ and $\quad \upsilon = \frac{\upsilon_0}{n}, \qquad (1.8)$

where r_0 and υ_0 are the parameters of the Bohr first orbit. The equalities (1.8) allowed adjusting formally the calculations to the experimental formula of the *H*-atom spectrum.

However, the equalities (1.8) contradict the conditions (1.1a) and (1.2a), as well as the equality (1.7) contradicts the equality (1.6). Accordingly, one should consider (1.7) and (1.8) as the fundamental faults of the Bohr theory, which were iterated in Schrödinger's equation. It should be also noted that n is an integer only for the homogeneous spherical field, in which the distance between stationary shells is constant.

At the transition of an electron from one shell to another, we regard its wave motion as the wave polarized in two mutually perpendicular planes. The energy of this electron is

$$E = \frac{1}{2}m\upsilon^2 + \frac{1}{2}m\upsilon^2 = m\upsilon^2. \qquad (1.9)$$

According to the equality (1.6), the electron's energy (1.9) can be also presented as

$$E = m\upsilon^2 = \hbar\omega = h\frac{c}{\lambda}. \qquad (1.10)$$

Thus, the main receiver, transmitter, and carrier of the energy quantum (1.10), both in the wave space of the *H*-atom and outside the space, is the ***wave quantum-electron*** (or the ***wave quantum-particle*****).** It is inadmissible without any proofs to ascribe this energy to the mystic mathematical point – photon – of the zero extension (size) and the zero rest mass, as it takes place in relativity theory.

The total electron's energy on any circular orbit is equal to zero. If the electron passes from the shell of the radius $r = r_0 n_1$ on to the further shell of the radius $r = r_0 n_2$, its kinetic energy decreases and the potential energy increases at the same quantity equal to the absorbed energy (1.10):

$$h\frac{c}{\lambda} = E_{p2} - E_{p1} = E_{k1} - E_{k2}, \qquad (1.11)$$

$$h\frac{c}{\lambda} = \left(-\frac{m\upsilon_2^2}{2}\right) - \left(-\frac{m\upsilon_1^2}{2}\right) = \frac{m\upsilon_1^2}{2} - \frac{m\upsilon_2^2}{2} = \frac{m\upsilon_0^2}{2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right). \qquad (1.11a)$$

From this, the formula of the *H*-atom spectrum and the Rydberg constant follow:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right), \qquad R = \frac{\upsilon_0}{4\pi r_0 c}. \qquad (1.12)$$

Let us clarify the wave nature of the Rydberg constant.

The electron, as only one node of the orbital wave, shows that only one half-wave of the fundamental tone, with the length twice as much the orbit length, is placed on the stationary orbit. In particular, the wave of the fundamental tone of the Bohr first orbit is $\lambda_0 = 4\pi r_0$. Because the electron's orbital velocity is its wave velocity on the orbit, the wave period of the fundamental tone is equal to $T_0 = \lambda_0/\upsilon_0 = 4\pi r_0/\upsilon_0$. The inverse wave of the fundamental tone in the wave space outside the *H*-atom (where the wave velocity is equal to c) is the Rydberg constant:

$$R = \frac{\upsilon_0}{4\pi r_0 c} = \frac{1}{T_0 c} = \frac{1}{\lambda_0}. \qquad (1.13)$$

For any stationary orbit, the Rydberg constant (according to (1.1a)) has the form

$$R_n = \frac{\upsilon}{4\pi r c} = \frac{1}{\lambda} = \frac{\upsilon_0/n}{4\pi r_0 n c} = \frac{1}{\lambda_0 n^2}. \qquad (1.13a)$$

The doubled difference of two Rydberg constants defines the ***spatial density of discreteness*** ρ_λ, generated at the wave excitation of the *H*-atom:

$$\rho_\lambda = \frac{1}{\lambda/2} = 2(R_1 - R_2) = \frac{2}{\lambda_0}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right). \qquad (1.14)$$

The density of discreteness defines the number of wave nodes of the wave-beam per unit of wavelength. Thus, the density of discreteness is the discrete parameter of the wave, which represents by itself a synthesis of discontinuous and continuous processes. When man walks on the snow, its feet circumscribe in space the continuous half-waves-steps, shifted in phase by a quarter-period. The footprints on the snow express the discontinuous (discrete) side of the motion. This is natural because man is a thinking wave system, which repeats general properties of all wave systems, including the “continuous wave steps” (waves) and “discontinuous wave steps” (nodes).

The Rydberg constant, as inverse of the wave of the fundamental tone, is the characteristic parameter of any wave system. For example, let us calculate the Rydberg constant of a musical string fixed at the opposite ends. The wave motion of such a string with the frequency of the fundamental tone ν_0 and the wavelength $\lambda_c = 2l$, where l is the length of the string, generates an acoustic wave in the ambient air of the same frequency with the Rydberg constant equal to

$$R = \frac{1}{\lambda_c} = \frac{\upsilon_0}{2cl}. \qquad (1.15)$$

Let us now imagine that the ends of the string are joined together, forming a string circle of the radius r_0 with one node. Then, the wavelength of the fundamental tone is $\lambda_c = 4\pi r_0$ and the formula (1.15) will be similar to the formula (1.13) for the *H*-atom.

The structure of the Rydberg constant of the *H*-atom completely rejects the quantum mechanics myth about the chaotic electron “orbitals-clouds” (i.e., about the absence of electron’s orbits-trajectories). Moreover, according to the common interpretation of the wave function, the maxima of squares of wave functions modules describe the electron orbits, most of which do not lie in the equatorial domain. These circular orbits on the radial shells are defined by the cones-extremes of the polar functions, which depict on the spheres the circular extremes-orbits. Because such orbits deny the Rutherford-Bohr atomic model, they conceal always and are unknown for large sections of the scientific community. The widespread popularization of the “excellent agreement” of quantum mechanics with the experiment, to which the “theory” has adjusted formally, encouraged this. This is not a case that Bohr, one of the creators of quantum mechanics, has stated that an agreement of a theory to the experiment does not quite mean that this theory is true.

The radii of spherical shells according to Schrödinger’s solutions, both extremes and zeros, are defined, in the main, by the irrational numbers n_r: $r = n_r r_0$. The exclusion are orbits for which $r = r_0 n^2$ that takes place at the condition $n = l - 1$. The spectral lines of the *H*-atom, corresponding to the irrational numbers n_r, do not exist in nature; however, quantum mechanics affirms the well agreement of its solutions with the experiment.

Remember, the radial solutions of Schrödinger’s equation increase unlimitedly in proportion as the radius of shells increase; therefore, such solutions were cut off artificially. But cut off solutions represent by themselves the functions of ***aperiodic*** ***processes***, which are in ***contradictory*** with the ***periodic*** ***wave processes of the atomic world***.

In addition, we can consider the cylindrical homogeneous wave field, in which only orbits proportional to squares of integer numbers, $r = r_0 n^2$, are selected. For such orbits, according to the formula (1.2a), the velocity is

$$\upsilon = \frac{\upsilon_0}{\sqrt{n^2}} = \frac{\upsilon_0}{n} \qquad (1.16)$$

and the orbital moment of momentum is represented by the expression

$$L = m\upsilon r = m\upsilon_0 r_0 n = \hbar n. \qquad (1.17)$$

The equality (1.17) expresses the Bohr postulate on stationary orbits. The electron’s potential energy on such orbits can be presented as

$$E = -\frac{L^2}{2J} = -\frac{\hbar^2 n^2}{2m(r_0 n^2)^2} = -\frac{\hbar^2}{2mr_0^2}\frac{1}{n^2}. \qquad (1.18)$$

On the basis of the law of conservation of energy (motion-rest), we obtain the following formula for electron's transitions from one orbit to another:

$$h\frac{c}{\lambda} = \Delta E = \frac{\hbar^2}{2mr_0^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right). \tag{1.19}$$

From this, the formula (1.13) follows as well.

Thus, in the cylindrical field on a subset of orbits $r = r_0 n^2$, the Bohr postulates are true. However, the aforementioned irrational selection of orbits gives rise to doubts, which, along with another effects, lead to the conclusion that the Bohr formal postulates do not correspond to reality.

2. *An electron as the wave quantum-particle*

The field of motions in the electron's equatorial plane is perceived, at the macrolevel, as a set of "lines of magnetic force", which are detected, by virtue of a small pitch (spacing), as closed lines. They are closed in the electron's space and unclosed in the outer space, related with the electron's motion along the Bohr orbit.

The world of particles-satellites of electrons is many orders as much the electron's size. Accordingly, for them, Earth is in the highest degree the "rarefied" spherical space of the shell structure. These particles pierce the Earth just freely as asteroids pierce the space of the solar system and galaxies. Just this world, called "magnetic field", surrounds a conductor with a current. This is the cylindrical field-space of the subatomic and subelectronic levels.

The amplitude electron wave (Fig. 2.1) is ***the wave of superstructure***, ***local wave***, ***oscillatory wave***. Each of the synonyms of the wave of superstructure expresses its definite sides (features). The wave of superstructure of an open microsystem generates in the surrounding field of matter-space-time ***the wave of basis*** (or ***the basis wave***) with ***the speed of basis c***.

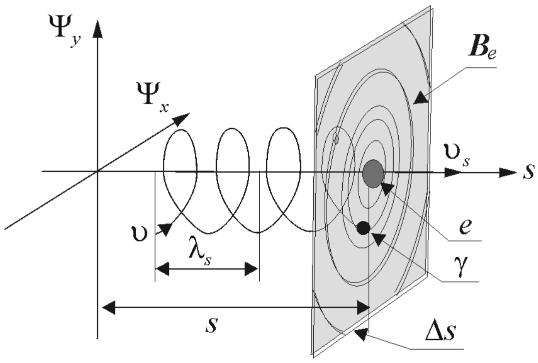


Fig. 2.1. The amplitude electron wave of an elementary part s of the orbit, as the superposition of two transversal waves-beams Ψ_x and Ψ_y; Δs is the thickness of the wave front as a four-dimensional physical plane; υ is the azimuth velocity of motion of electron's satellites; λ_s is the axial wavelength; υ_s is the axial velocity of the wave-beam along the orbit; e is the electron; γ is the electron's satellite; B_e is the transversal cylindrical ("magnetic") field of the electron – the field of all its satellites with the lower situated fields of matter-space.

The waves of superstructure and basis consist of separate processes-quanta, bounded in space by the wavelength and period. Such periods-quanta should be called ***wave quanta***, ***wave-beam quanta***, or ***quanta of wave***. The wave process, limited by the length of half-wave, defines the wave ***half-quantum***. One should distinguish ***the wave quanta and half-quanta of superstructure and basis***. The waves of superstructure and basis form the unit ***wave complex of basis-superstructure***. Its complex quantum is ***the wave quantum of basis-superstructure***.

Because the space of the Universe is a system of an infinite series of embedded spaces, each wave of superstructure is simultaneously the wave of basis for the more complicated wave structures. Contemporary physics operates with the atomic level of the field of matter-space-time. It represents by itself the level of superstructure, with a series of sublevels, over the field of matter-space-time, which embraces atomic levels of superstructure. This field is the field of basis with the wave speed c (speed of light).

The amplitude electron wave of space-time of superstructure is characterized by ***the wave quantum of superstructure***. The extension of the quantum is defined by the quantum-length of the wave of superstructure λ_υ and, in the time field, by the quantum-length T, called the wave period. The wave quantum of superstructure generates, in the space of basis, ***the wave quantum of basis***. Its extension, in the space of basis, is defined by the quantum-length of the wave of basis λ and its period T. Thus, in the wave time field, the extension of quanta of superstructure and basis is the same.

In the simplest case, all calculations, related with the interaction and transformation of waves, come to the relation between the wave quanta, or half-quanta.

In a case of the electron wave, the wave quantum is defined by the length of the wave of the fundamental tone and by the corresponding wave period (the time length of the wave of the fundamental tone). The discrete component of the wave electron quantum is an electron. Accordingly, the *wave quantum of the electron wave* can be called ***the wave quantum-electron*** or simply ***the wave quantum-particle***. Such terms (names) reflect the contradictory ***continuous-discontinuous*** character of the wave quantum, in which the continuous component is represented by the wave motion and the discontinuous (discrete) one – by the electron (particle).

The wave motion of electron's satellites in the space of an electron orbit can be presented approximately over the superposition of two transversal potential-kinetic x- and y-waves-beams, shifted in phase by a quarter-period:

$$\Psi_x = re^{i(\omega t - k_S s + \alpha)}, \qquad \Psi_y = ire^{i(\omega t - k_S s + \alpha)}. \tag{2.1}$$

where k_s is the wave orbital number and s is the displacement along the orbit.

The waves of x- and y-beams form the amplitude spiral wave-beam. In every instant, the electron, through its cylindrical field, forms a front of the spiral wave-beam. Simultaneously, the electron, as a microgalaxy, circumscribes the relative circular trajectory with the amplitude velocity $\upsilon = r\omega$, where r is the radius of the spiral line-beam (wave spiral). Circular trajectories, lying in planes in parallel to axes x and y, are relatively closed and, simultaneously, they are absolutely unclosed because presented by the electron spiral (Fig. 2.1).

The orbital motion of electron's satellites in the equatorial plane is the closed circular trajectory, but in the outer space, the satellites move along the spiral trajectory with the pitch (spacing), representing by itself the axial half-wave on the Bohr orbit:

$$l_h = 2\pi r ctg\varphi = 2\pi r \frac{\upsilon_s}{\upsilon}, \tag{2.2}$$

where r is the radius of the circular trajectory of electron's satellite and $\varphi = arctg(\upsilon/\upsilon_s)$ is the inclination of the spiral trajectory to the Bohr orbit. For definiteness, we will consider the motion along the Bohr first orbit of the radius r_0, then, $\upsilon_s = \upsilon_0$ is the Bohr first velocity.

In proportion as the distance between the electron and satellites increases, their orbits transform gradually into ellipses with large half-axes a and eccentricities ε satisfying the condition

$$a(1-\varepsilon) = r_0. \tag{2.3}$$

This is natural, because the center of the Bohr first orbit represents, at such a motion, the general perihelion of all orbits of satellites.

The projection of the amplitude electron wave-beam, limited by a small part of the trajectory, on the arbitrary plane xoz describes its geometry by the electron waves-beams of potential-kinetic displacements, charge, and current:

$$\Psi_x = re^{i(\omega t - k_z z + \delta)}, \quad Q_x = e \cdot e^{i(\omega t - k_z z + \alpha)}, \quad I_x = \omega e \cdot e^{i(\omega t - k_z z + \alpha + \pi/2)}, \tag{2.4}$$

and by the other parameters. The potential-kinetic structure of any elementary parameter, as the time wave, can be presented by a graph of the wave-beam (Fig. 2.2). The same is the structure of any elementary waves-beams of the subatomic level of the wave field of matter-space-time.

If the azimuth velocity of electron's motion is υ and the axial velocity of the electron wave is $\upsilon_z = c$, then, the length of the axial wave of the fundamental tone will be

$$\lambda_z = 4\pi r ctg\varphi = 4\pi r \frac{c}{\upsilon}. \tag{2.5}$$

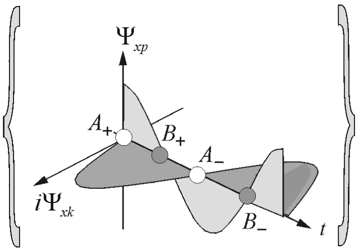
$\Psi_x =$ 

Fig. 2.2. A graph of the potential-kinetic wave-beam; A_+ and A_- are the potential nodes, B_+ and B_- are the kinetic nodes.

The wave action of the electron wave of the fundamental tone takes the form

$$h_\lambda = \lambda_z p = \lambda_z m\upsilon = 4\pi r m\upsilon = 2h\,, \tag{2.6}$$

where

$$h = 2\pi r m\upsilon \tag{2.6a}$$

is the half-wave action, called the Planck constant. For the sake of simplicity, we usually omit the index z of the wave λ_z.

In the spherical-cylindrical field, the amplitudes of velocities of microobjects of the subatomic level are defined, as shows experiment, rather through the spherical field (1.1): $\upsilon = \dfrac{\upsilon_s}{kr}$, where υ_s is the amplitude of velocity corresponding to the condition $kr = 1$, i.e., when only one wave $\lambda = 2\pi r$ is placed on the circular orbit. We call such a wave the unit wave and denote it also by the symbol λ_e.

As follows from (1.1), the specific elementary wave (and half-wave) actions of particles are the constants of the wave, and the wave field on the whole:

$$\frac{h_\lambda}{m} = 4\pi r\upsilon = \frac{4\pi\upsilon_s}{k} = const\,, \tag{2.7}$$

$$\frac{h}{m} = 2\pi r\upsilon = \frac{2\pi\upsilon_s}{k} = ƛ\upsilon_s = const\,. \tag{2.8}$$

In the cylindrical field (see (1.2)), $\upsilon = \upsilon_c / \sqrt{kr}$ and the constant υ_c, similar as the case of the spherical wave, is related with the unit wave through the frequency ω_e; therefore, if $k = \omega_e / \upsilon$, then $\upsilon_c^2 = \upsilon r\omega_e$. Hence, the amplitude energy of any particle of mass m in the unit wave will be defined by the expression

$$m\upsilon_c^2 = m\upsilon r\omega_e = \hbar\omega_e = h\frac{\upsilon}{\lambda_\upsilon} = h\frac{c}{\lambda_e}\,, \tag{2.9}$$

where λ_υ is the unit wave of superstructure and λ_e is the unit wave in the ambient space (the wave of basis), caused by the wave of superstructure.

For the wave of the fundamental tone, $\omega = \tfrac{1}{2}\omega_e$ and $k = \omega r / \upsilon = \tfrac{1}{2}$, therefore, the kinetic energy of a particle in such a wave has the form

$$E = \frac{m\upsilon^2}{2} = \frac{m}{2}\frac{\upsilon_c^2}{\tfrac{1}{2}} = m\upsilon_c^2 = \hbar\omega = h\frac{\upsilon}{\lambda_\upsilon} = h\frac{c}{\lambda}\,. \tag{2.10}$$

The frequency of the wave of the fundamental tone is the same both in space of the superstructure and the basis:

$$\nu = \upsilon / \lambda_\upsilon = c / \lambda\,, \tag{2.11}$$

where $\lambda_\upsilon = 4\pi r$ is the wave of superstructure and $\lambda = cT$ is the basis wave.

The electron quantum of the wave of superstructure is characterized by the electron's kinetic energy, which is presented in the form $E = m\upsilon^2/2$ and in the form of energy of the wave quantum $E = h\upsilon / \lambda_\upsilon$. Both forms of energy, as follows from the equalities (2.10), are equal. Of course, these measures of energy do not exhaust completely the potential-kinetic energy of the wave quantum. However, the usage of these measures gives, in a definite extent, an agreement with the experiment.

The energy of the wave quantum of superstructure $E = h\upsilon / \lambda_\upsilon$ generates, at the level of basis, the equal energy of the wave quantum of basis $E = hc / \lambda$.

3. *Parameters-quanta of the electron wave quantum-beam*

The inverse wavelength is the important parameter of the wave quantum. It defines ***the nodal density*** N_n ***– the number of kinetic and potential nodes per unit of length of the basis space***:

$$N_n = \frac{4}{\lambda} = \frac{2}{l_z} = \frac{1}{\pi r} tg\varphi = \frac{1}{\pi r}\frac{\upsilon}{c} = \frac{\upsilon_0}{\pi r_0 c}\frac{1}{n^2} = \frac{2}{T_c c}\frac{1}{n^2} = \frac{4}{\lambda_0 n^2} = 4R_n\,, \tag{3.1}$$

where
$$R_n = \frac{\upsilon}{4\pi r c} = \frac{1}{\lambda} = \frac{\upsilon_0/n}{4\pi r_0 n c} = \frac{1}{\lambda_0 n^2} \tag{3.2}$$

is the Rydberg constant of the n-shell. The nodal density defines ***the wave density*** $N_{\lambda n}$ – the number of waves per unit of the extension (length) of space,

$$N_{\lambda n} = \frac{N_n}{4} = \frac{1}{\lambda} = R_n = \frac{R}{n^2}\,, \tag{3.3}$$

and the corresponding ***density of half-waves***

$$N_{\lambda n/2} = \frac{N_n}{2} = \frac{2}{\lambda} = 2R_n = \frac{2R}{n^2}\,. \tag{3.4}$$

Thus, the wave density $N_{\lambda n}$ and the Rydberg constant R_n are the synonyms of the same property of the wave space.

The nodes of the wave field of space are inseparable of the time nodes of the wave field of time. Therefore, it makes sense to consider the ***density of time nodes***:

$$Z_n = cN_n = \frac{\upsilon}{\pi r} = \frac{\upsilon_0}{\pi r_0}\frac{1}{n^2} = \frac{2}{T_{e0}}\frac{1}{n^2} = 2\nu_{e0}\frac{1}{n^2}\,, \tag{3.5}$$

and the ***linear density of waves of time*** (***frequency***)

$$Z_{\lambda n} = \frac{c}{\lambda} = \frac{1}{4}cN_{\lambda n} = \frac{\upsilon}{4\pi r} = \frac{cR}{n^2} = \frac{1}{T_0}\frac{1}{n^2} = \nu_0\frac{1}{n^2}\,, \tag{3.6}$$

where $T_0 = 2T_{e0}$ is the wave period of the fundamental tone of the Bohr first orbit and T_{e0} is the period of revolution on it, representing by itself half-period of the wave of the fundamental tone. The ***density of half-waves of time*** is

$$Z_{\lambda n/2} = \frac{1}{2}cN_{\lambda n} = \frac{\upsilon}{2\pi r} = \frac{2}{T_0}\frac{1}{n^2} = 2\nu_0\frac{1}{n^2}\,. \tag{3.7}$$

In the light of introduced notions of density, the value of average current

$$I = \frac{2}{\pi}\omega e = \frac{4e}{T} = \frac{2e}{T_e} \tag{3.8}$$

is the nodal density of the wave charge, related with the waves of space and time. The nodal density of ***charge*** defines its ***wave density***

$$I_\lambda = \frac{1}{4}I = \frac{e}{T} = \frac{e}{2T_e}\,. \tag{3.9}$$

The ***half-wave density of charge*** is

$$I_{\lambda/2} = \frac{1}{2}I = \frac{2e}{T} = \frac{e}{T_e}\,, \tag{3.10}$$

In classical physics, the last wave measure was erroneously accepted as the average value of the orbital current (regarded as a mechanical flow of “electric liquid” along the orbit).

All above-presented densities are ***parameters-quanta of the electron wave quanta-beam***. They have general character and relate to many wave processes.

4. *The wave interaction and the laws of conservation*

Let us agree to call an arbitrary particle of the subatomic level δ-particle. The kinetic energy of its wave quantum can be presented in the following form:

$$E_\delta = \frac{1}{2}m_\delta \upsilon^2 = \frac{1}{2}m_\delta \upsilon r\omega_e = \frac{1}{2}m_\delta \upsilon r\frac{2\pi}{T_e} = \frac{1}{2}m_\delta \upsilon r\frac{4\pi}{T} = 2\pi m_\delta \upsilon r\nu = h_\delta \nu = h_\delta\frac{c}{\lambda}\,, \tag{4.1}$$

where $h_\delta = 2\pi m_\delta \upsilon r$ is the wave action of δ-particle.

The same in value, but opposite in sign, is the value of potential energy, if we consider the circular amplitude wave quanta:

$$E_{\delta p} = -\frac{1}{2} m_\delta \upsilon^2 = -h_\delta \frac{c}{\lambda}. \qquad (4.1a)$$

The energy E_δ represents the huge world of particles of the subatomic level, which modern physics regard as an abstract field. First of all, these particles are satellites of electrons. According to the equation (4.1), the kinetic and potential field energies of such particles can be presented as

$$E_{\delta mk} = h_\delta \frac{c}{\lambda_{mk}} = h_\delta \nu_0 \frac{1}{m_k^2}, \qquad E_{\delta pmk} = -h_\delta \frac{c}{\lambda_{mk}} = -h_\delta \nu_0 \frac{1}{m_k^2}, \qquad (4.2)$$

where m_k is the relative radius of the azimuth orbit, expressed in radii of the Bohr first orbit.

If the incident wave interacts with an object A and the potential energy of the wave increases, the properties of the wave change. Such a wave is called the wave of absorption of energy. If after the interaction the potential energy of the wave decreases, an additional wave of radiation, taking away with one the excess energy (Fig. 4.1), arises.

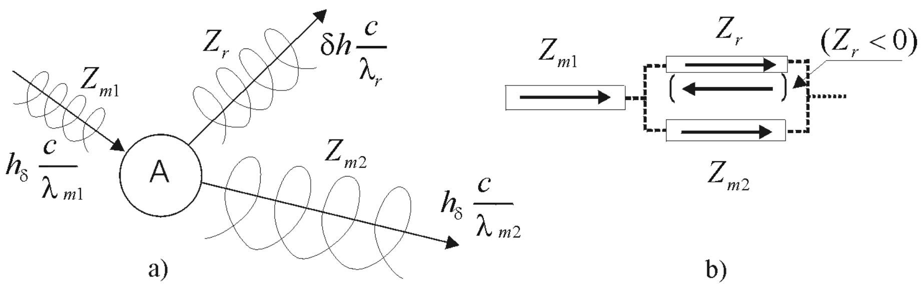


Fig. 4.1. A graph of wave interactions (a): Z_{m1} is the linear density of the initial wave of time, Z_{m2} is the linear density of the wave of time after interaction, and Z_r is the linear density of radiation of the wave of time; an equivalent scheme of the data of wave processes, as waves currents, in which the linear densities are the specific wave conductivities (b).

Such an interaction (at the subatomic level) is expressed over the principle of conservation of energy ***at the level of wave quanta***:

$$E_{\delta pm1} + E_r = E_{\delta pm2}, \qquad (4.3)$$

where

$$E_{\delta pm1} = -h_\delta \frac{c}{\lambda_{m1}} = -h_\delta \nu_0 \frac{1}{m_1^2} \qquad (4.3a)$$

is the potential energy of the wave quantum of an incident wave-particle,

$$E_{\delta pm2} = h_\delta \frac{c}{\lambda_{m2}} = -h_\delta \nu_0 \frac{1}{m_2^2} \qquad (4.3b)$$

is the potential energy of the wave quantum of an incident wave-particle after

the interaction, and

$$E_{r1} = h_\delta \frac{c}{\lambda} \qquad (4.3c)$$

is the energy of the wave quantum of radiation (absorption).

From the equation (4.3), the law of conservation of frequency or, that is the same, the law of linear density of waves of time, follows:

$$\frac{c}{\lambda_{m1}} = \frac{c}{\lambda_{m2}} + \frac{c}{\lambda}, \qquad (4.4)$$

as well as the law of linear density of waves of space,

$$\frac{1}{\lambda_{m1}} = \frac{1}{\lambda_{m2}} + \frac{1}{\lambda}. \qquad (4.4a)$$

Both laws represent, simultaneously, the law of conservation of density of the number of wave potential and kinetic nodes, which are related with the states of the wave field of time and space:

$$Z_{m1} = Z_{m2} + Z_r\,, \tag{4.5}$$
$$N_{m1} = N_{m2} + N_r\,. \tag{4.5a}$$

Thus, resting on any of the laws of conservation for wave quanta, for example, on the law of conservation of energy (4.3), we arrive at

$$E_r = E_{\delta m1} - E_{\delta m2} = h_\delta \frac{c}{\lambda} = h_\delta \nu_0 \left(\frac{1}{m_1^2} - \frac{1}{m_2^2} \right).$$

Hence, the length of the radiated (absorbed) wave is

$$\frac{1}{\lambda} = \frac{\nu_0}{c} \left(\frac{1}{m_1^2} - \frac{1}{m_2^2} \right). \tag{4.6}$$

The above-considered waves are simultaneously the waves of currents. In such a case, the incident wave is the general current. The wave after interaction and the wave of radiation are the two parallel processes-currents, as the parallel elements of the wave chain of exchange of motion-rest (Fig. 4.1b).

For the wave spherical part of the field, as the field of the spherical current, we obtain, according to the elementary Ohm's law, the following wave quantum of the specific resistance:

$$\rho = \frac{R_{res} S}{l} = \frac{S}{l}\frac{\varphi}{I} = \frac{4\pi r^2}{r}\frac{e}{4\pi\varepsilon_0 r \omega_e e} = \frac{1}{\varepsilon_0 \omega_e} = \frac{m}{\varepsilon_0 e}\,, \tag{4.7}$$

where m and e are the electron's mass and charge; $\omega_e = e/m$ is the fundamental frequency of the field of electron level.

The specific resistance, at the constant charge, is proportional to mass. And the specific conductivity and the circular frequency are, in essence, the same parameter, presented in the different forms:

$$\sigma = \frac{1}{\rho} = \varepsilon_0 \omega_e = \frac{\varepsilon_0 e}{m}\,. \tag{4.8}$$

Let us return to the law (4.4). We will present it in the form of the law of conservation of circular frequencies:

$$\omega_{m1} = \omega_{m2} + \omega_r\,. \tag{4.9}$$

According to the formula (4.8), this law can be also presented as

$$\sigma_{m1} = \sigma_{m2} + \sigma_r \tag{4.9a}$$

or

$$\frac{1}{\rho_{m1}} = \frac{1}{\rho_{m2}} + \frac{1}{\rho_r}\,. \tag{4.9b}$$

These are the laws of parallel connection of wave chains-currents. They show that the initial wave-beam bifurcates into two parallel waves-beams, one of which is the wave of radiation and another one is the transformed initial wave (Fig. 4.1b). If a wave λ_r is radiated, then $Z_{m1} > Z_{m2}$, $\omega_r > 0$, and $\rho_r > 0$. If the same wave is absorbed, we have $Z_{m1} < Z_{m2}$ and, then, $\lambda_r < 0$, $\omega_r < 0$, and $\rho_r < 0$.

Let us now consider the wave interaction at the level of electron waves, when the space of a conductor is treated with waves of δ-particles of a definite frequency. As a result of such action, in the space of a conductor, the relatively intensive electron waves-currents of the same frequency arise. They can leave the space of a conductor. This process is called the *photoelectric effect*. The scheme of interaction for the electron wave quanta-currents, in this case, is analogous to one presented in Fig. 4.1.

The electron wave quantum of current, with the relatively high energy, overcomes the space of a conductor. Losing on its way a part of energy, it excites the wave quanta of δ-particles and leaves the conductor. Outside the space of the conductor, the wave quantum-electron is perceived, in the electron wave, above all, as an individual electron and then, as a wave. The law of conservation of energy for the wave electron quanta has the form

$$E_e = \frac{1}{2} m \upsilon_0^2 = h\frac{c}{\lambda} = \sum_k E_{\delta k} + \frac{1}{2} m \upsilon^2 \tag{4.10}$$

or briefly
$$h\frac{c}{\lambda} = A + \frac{1}{2}m\upsilon^2 , \tag{4.11}$$
where $E_e = \frac{1}{2}m\upsilon_0^2 = h\frac{c}{\lambda}$ is the kinetic energy of the initial wave quantum, $A = \sum_k E_{\delta k}$ is the energy of the wave quantum of scattered wave in the space of a conductor (which is called the work function), and $\frac{1}{2}m\upsilon^2$ is the kinetic energy of electron outside the space of a conductor.

At last, let us assume that fast electrons are accelerated under the potential difference V up to the energy
$$eV = \frac{1}{2}m\upsilon^2 = h\frac{c}{\lambda_{\min}} \tag{4.12}$$
and hit an anticathode of a roentgen tube. Then, at braking, their energy is partially scattered on the surface of anticathode. Another part of electrons with the wave energy
$$h\frac{c}{\lambda_\delta} = eV - E_r , \tag{4.13}$$
where E_r is the electron's energy absorbed by atoms of the anticathode, induces the waves of δ-particles of the subatomic level of the same length λ_δ and of high energy. Such waves are called X-rays. Fast electrons, exciting the wave atomic space, cause a discrete series of characteristic waves against the background of bremsstrahlung δ-radiation.

If an elastic interaction of an electron takes place ($E_r = 0$), then, according to the equality (4.13), the length of the electron wave, and generated waves of δ-particles, will be minimal and equal to
$$\lambda_{\min} = h\frac{c}{eV} , \tag{4.14}$$
which defines the lower boundary of waves of roentgen spectrum.

5. *The mass of "thickening", m_r , as the wave quantum-quasiparticle*

Let us consider the wave dynamics at the level of the axial wave of basis. In the wave process, the change of the extension Δl of the wave element of space (along the wave-beam) takes place. Simultaneously, the change of the field mass, Δm, related with the element of space l, occurs. The following relation approximately expresses this peculiarity:
$$\frac{\Delta l}{l} = \frac{\Delta m}{m} . \tag{5.1}$$
The Δl is the local change, therefore, $\Delta l = \upsilon\Delta t$. But $l = c\Delta t$, hence, we obtain
$$\frac{\Delta l}{l} = \frac{\Delta m}{m} = \frac{\upsilon}{c} = \frac{\omega a}{c} = ka , \tag{5.1a}$$
where a is the amplitude of axial displacement.

The axial element of the ***mass of "thickening***" (the *mass of radiation and scattering*) along the wave-beam of basis is defined by the equality
$$m_r = \Delta m = \frac{\upsilon}{c}m = mka . \tag{5.2}$$
In the limiting case, when $\upsilon = c$, the field wave mass is equal to $m_r = m$.

This mass takes part both in the wave motion of superstructure and the wave motion of basis. The same measure of scattering of mass (5.2) is obtained from the wave analysis of the central field of exchange (see the authors books). When we speak about the mass of radiation-scattering, one must keep in mind that means the wave perturbation of exchange raised above the equilibrium exchange of matter-space-time.

If m is the electron mass and υ is the Bohr velocity, then, the amplitude mass of radiation is
$$m_{rm} \approx \frac{1}{137}m , \tag{5.3}$$

and its average quantum is $$m_r = \frac{\upsilon}{2c} m = \frac{1}{274} m \,. \qquad (5.3a)$$

The local momentum (momentum of superstructure) p_r of the quantum of mass of radiation m_r can be presented by Louis de Broglie's formula as

$$p_r = m_r \upsilon = \frac{m\upsilon^2}{2c} = \frac{h}{\lambda} \,. \qquad (5.4)$$

It should be noted that the electron's kinetic energy, the kinetic energy of the wave quantum of the electron wave of the length λ, and the kinetic energy of superstructure-basis of the particle m_r are equal:

$$\frac{hc}{\lambda} = \frac{m\upsilon^2}{2} = \frac{1}{2}\frac{\upsilon}{c} m\upsilon c = m_r \upsilon c \,. \qquad (5.5)$$

Possibly, this equality is valid for the field mass of the particle m. A question arises. What can measures of masses of radiation-scattering exist? Before the answer to this question, it should be noted once more that the electron's mass is at the level of the fundamental measure:

$$m_{ei} = \frac{2\pi \log e}{3} \cdot 10^{-27} g \,. \qquad (5.6)$$

This measure of mass possibly fairly often appears in wave processes.

One should regard the wave "thickening" m_r as the wave quasiparticle. If its mass turns out to be equal to (5.6), this particle can be regarded as a quasielectron, or a wave electron, participating only in the wave process of radiation and absorption. For the unit wave, the following relation is valid:

$$\frac{m_r}{m_\lambda} = \frac{\upsilon}{c} = \frac{2\pi a}{\lambda} \qquad (5.7)$$

and $$m_\lambda = \frac{c}{\upsilon} m_r \,, \qquad (5.8)$$

where m_λ is the field mass, related with the quantum of the wave λ.

If υ is the Bohr velocity, corresponding to the amplitude a equal to the Bohr radius, and m_r is the quasielectron, then, the mass of radiation of the unit wave quantum is

$$m_\lambda \approx 137 m_r \qquad (5.9)$$

It is natural to compare this wave quantum with the γ-quantum of the same mass of exchange. Correspondingly, the wave quantum of the fundamental tone has twice as much mass

$$m_\lambda \approx 274 m_r \,, \qquad (5.10)$$

This quantum should be compared with the π-meson mass. In such a case, the wave decay reaction

$$\pi \rightarrow \gamma + \gamma \qquad (5.11)$$

should be treated as decomposition of the wave quantum of the fundamental tone into two half-quanta of this tone or two quanta of the unit wave.

Let roentgen rays (the rays of some δ-particles of high energies) interact with free electrons of some space. Then, partial scattering of rays and partial absorption of the energy, by free electrons of the space, take places (Fig. 5.1).

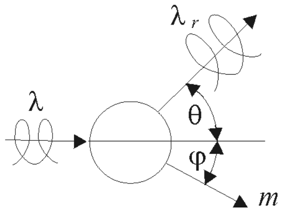


Fig. 5.1. Compton scattering.

In the language of wave quanta, the laws of conservation in such a process take the form:

$$\frac{h}{\lambda}\mathbf{n} = \frac{h}{\lambda_r}\mathbf{r} + m\mathbf{v} \qquad \text{and} \qquad \frac{hc}{\lambda} = \frac{hc}{\lambda_r} + \frac{m\upsilon^2}{2} \,, \qquad (5.12)$$

where λ and λ_r are the initial wave and the wave after the interaction, respectively, m is the electron mass.

On the basis of the equalities (5.12), we obtain the Compton difference of scattered and incident waves

$$\Delta\lambda = \lambda_r - \lambda = \frac{\lambda_0}{2m} m_r (1 - \cos\theta) = \frac{\lambda_e}{m} m_r (1 - \cos\theta) , \qquad (5.13)$$

where m_r is the wave mass of δ-particles of X-rays, $\lambda_0 = 4\pi r_0$ is the Bohr wavelength of the fundamental tone, and $\lambda_e = 2\pi r_0$ is the length of the unit wave. In this equality, the ratio $\frac{\lambda_e}{m}$ is the specific density of the wave extension, because one quantum of the electron mass is related with the unit wave. From the expression (5.13), one can estimate the mass of the roentgen quasiparticle:

$$m_r = \frac{\Delta\lambda}{\lambda_e (1 - \cos\theta)} m . \qquad (5.14)$$

This formula is approximate, because the fixed electrons also take part in the scattering of X-rays and the mass m, entering in the equation (5.14), is some effective mass.