



# On the Semi-classical Approach to the Physical Axiomatic of Quantum Mechanics and the New Wave-Particle Interpretation of Light

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**Abstract:** A new approach to the physical axiomatic of quantum mechanics is proposed. The basis of this approach is the rejection of the idea of an electron as a point particle. To describe the dynamics of the material substance of the electron, a new AMT (Action-Matter-Transfer) equation based on the Hamilton-Jacobi equation is proposed. This nonlinear equation simply transforms into the Schrödinger equation which becomes an intermediate step for solving a more general equation that describes the actual mass and charge density of an electron cloud. The dimensionless density of the material substance of the electron is equal to the square of the wave function. The nonlinearity of the AMT-equation make us question the validity of the quantum mechanical principle of superposition. The representation of an electron as a cloud with a distributed density helps to explain the interference effects in the well-known double-slit experiment. It is shown that light emission can occur in full accordance with classical electrodynamics when the material substance of an electron is spatially redistributed. Our approach makes it possible to interpret light as a chain of photons, each of which represents a “particle” of an electromagnetic wave propagating in space. The direction of radiation can be determined by the axis of rotation of the electron cloud due to the presence of the spin which turns the electron into elementary magnet, so the two electron clouds can form in an atom a stable structure of paired electrons in the form of two hemispheres rotating in one direction. In the framework of the quasi-classical concept of photon generation, the processes of reflection of light, its transmission through a transparent medium, and birefringence are discussed as well as Compton effect and laser emission.

**Keywords:** Axiomatic of Quantum Mechanics, Wave Function, Electron Cloud, Photon Generation, Light Reflection, Birefringence

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## 1. Introduction

About a hundred years ago, the works of Erwin Schrödinger laid the mathematical foundation of quantum mechanics [1, 2]. However, the physical meanings of the Schrödinger equation and the wave function  $\Psi$  entering into it were not clear even to their creator. An important step, inspired by many scientists, towards classical theory was made by David Bom. He found in the Schrodinger equation "roots" leading to the continuity and Hamilton-Jacobi equations [3]. The strange probabilistic interpretation of the squared wave function  $\Psi^2$  could not satisfy all physicists. “God does not play dice”, – in this part of his famous phrase, the great Albert Einstein expressed his attitude to the

probabilistic interpretation of quantum mechanics. And even Erwin Schrödinger himself in his “Four Lectures on Wave Mechanics” stated [4]: “It is necessary to postulate that the square of the absolute value of the wave function is proportional to the electric charge density, which carries out radiation in accordance with the laws of ordinary electrodynamics.” This Schrödinger hypothesis did not receive proper continuation and development, possibly because it contradicted the generally accepted notion of an electron as a point particle. In this paper, we will try to eliminate this omission.

## 2. New Theoretical Concept and Basic Equations

Five years ago, in [5], a new approach to the interpretation of quantum-mechanical phenomena was proposed. Later, in [6], a theoretical attempt was made to construct a consistent picture of the behavior of matter at the atomic and subatomic levels. Conditions and solutions were proposed that link classical mechanics with quantum one. The essence of these proposals is as follows.

First of all, we fundamentally abandon the "point" idea of the electron. We believe that the electron consists of primary matter having mass  $m$  and electric charge  $e$  distributed over its volume  $V$ . The density of matter  $\rho$  must satisfy the equation:

$$\int \rho dV = 1 \quad (1)$$

This condition obviously follows from the assumption that the mass and charge of an electron are distributed over its volume with densities  $m\rho$  and  $e\rho$ , so  $\int m\rho dV = m$  and  $\int e\rho dV = e$ . By another immanent characteristic of an electron we assume an action distributed over its matter with a density  $(-h/2 \cdot \rho)$ , where  $h$  is the quantum of action, Planck's constant. Action  $S$  as a physical abstract category, introduced into scientific use in the middle of the 18th century, tracks the energy content of material substance. The source for the action in accordance with the Hamilton-Jacobi equation ( $\partial S / \partial t + H = 0$ , where  $H$  is the Hamiltonian, the sum of the potential and kinetic energy) is the energy  $E$ , which can be either external or internal. We assume that the energy and action are distributed over the material substance of the electron with the corresponding densities  $E\rho$  and  $(-E\rho t - \rho h / 2)$ , so that the integral over the volume of the particle gives their full values. Since the local change in action should take into account the divergence of its internal flows, determined by the factor  $(-h/2) \operatorname{div} \rho \vec{v}$  (where  $v$  is the speed of the internal motion of matter), we can write an analog of the Hamilton-Jacobi equation in its differential form:

$$-\frac{h}{2} \frac{\partial \rho}{\partial t} - \frac{h}{2} \operatorname{div} \rho \vec{v} - E\rho + \frac{m\rho v^2}{2} + U\rho = 0 \quad (2)$$

Here, the kinetic and potential energies (the last two terms) are written in classical form: for example, in the case of a hydrogen atom,  $U$  is the Coulomb potential proportional to  $e^2$ . And the energy  $E$  is not the energy of the particle as a whole, but the energy received from the outside (for example, during the absorption of a photon). Note that (2) can be "divided" into two classical equations: continuity and energy conservation. To simplify and solve equation (2), it is necessary to postulate one more condition that helps to estimate the velocity  $v$ . This condition is similar to the classical laws of Fick and Fourier, and it establishes a proportionality between the density gradient of matter and its flow. We will write it in canonical form: the gradient of immanent action is equal to the internal impulse:

$$-\frac{h}{2} \nabla \rho = m\rho \vec{v} \quad (3)$$

Note that (3) contains the physical basis of the Heisenberg uncertainty relation. Indeed, the stronger the particle is localized (the larger the modulus  $\nabla \rho$ ), the higher the velocity of the corresponding element of material substance. Substituting Eq. (3) into Eq. (2), we obtain the transfer equation for the density of matter, which in [6] was called the AMT (Action-Matter-Transfer) - equation.

$$\frac{h}{2} \frac{\partial \rho}{\partial t} + \frac{h^2}{4m} \nabla^2 \rho + E\rho - \frac{h^2}{8m\rho} (\nabla \rho)^2 - U\rho = 0 \quad (4)$$

In this peculiar transfer equation there is both a "diffusion" term (the second in the equation) and a nonlinear term proportional to  $(\nabla \rho)^2$ , reflecting the kinetic energy of internal flows. Energy  $E\rho$  acts as a "source" of action, and potential energy  $U\rho$  acts as a "sink". Stopping some transient process ( $\partial \rho / \partial t \rightarrow 0$ ), we get the stationary AMT-equation:

$$-\frac{h^2}{4m} \nabla^2 \rho + \frac{h^2}{8m\rho} (\nabla \rho)^2 = E\rho - U\rho \quad (5)$$

By simple substitution  $\rho = \psi^2$ , this equation is easily transformed into the stationary Schrödinger equation. In order to avoid doubts about the mathematical perfection of this transformation, we give algebraic calculations.

$$\nabla^2 \rho = \nabla(2\psi \nabla \psi) = 2(\nabla \psi)^2 + 2\psi \nabla^2 \psi \quad (6)$$

$$(\nabla \rho)^2 = (2\psi \nabla \psi)^2 = 4\psi^2 (\nabla \psi)^2$$

Substituting Eq. (6) into Eq. (5), we obtain the stationary Schrödinger equation in its classical form. Thus, thanks to the AMT-equation, we "rid" the quantum theory of such a physical super-abstraction as an imaginary unit, as well as of absolutely non-physical virtual waves of matter (De Broglie waves) associated with it. So, there is a "genetic" relationship between the Schrödinger equation and the AMT equation, which allows us to draw interesting conclusions. On the one hand, there are no conditions for the mathematical substantiation of such a phenomenon as quantum-mechanical superposition, since it was a consequence of the linearity of the Schrödinger equation with respect to wave functions  $\psi$ . In the case of the AMT equation, which is substantially nonlinear with respect to  $\rho$ , the sum of the solutions ( $\rho_1 + \rho_2$ ) is not its solution. On the other hand, to any solution of the Schrödinger equation in the form of the sum of  $N$  wave functions there corresponds a solution of the AMT equation in the form:

$$\rho = \left( \sum_{i=1}^N \psi_i \right)^2 \quad (7)$$

It is clear that Eq. (7) satisfies the normal condition for the

total amount of matter  $\int \rho dV = N$ , since the integrals of the products of the wave functions  $\psi_i \psi_j$  ( $i \neq j$ ) are equal to zero due to the orthogonality of these functions. And we have a state of  $N$  electrons with a distributed density of matter:

$$\rho = \sum_{i=1}^N \rho_i + \sum_{i,j=1}^N 2\psi_i \psi_j \quad (8)$$

Since  $\rho_i = \psi_i^2$  and the distribution of the density of electron matter in free space is a half-sinusoid, the phase difference between the particles, each passing through its own slit (the famous experiment with two slits), creates conditions for interference. The maxima  $\rho_i$  of neighboring particles can overlap each other and increase in this place the total value of the local kinetic energy  $m\rho v^2/2$ , which should cause there either a glow (photoelectric effect) or darkening of the photographic plate.

Let us now turn to the double-slit experiment. In various versions of it, the electron beam accelerated by the potential difference  $U$  to the energy  $eU$  was divided into two flows by slits [7] or by a thin wire [8] and then hit the screen, where the detection of electrons produced an interference pattern. The interpretation of the observed effect on the basis of the AMT- equation does not formally differ from the "classical" quantum-mechanical interpretation [9]. Indeed, the two electrons that have passed each through their slit represent "clouds" of matter with a modulated density. The pair of electrons closest to each other comes into contact. Their general state should be described by a function  $\rho_{12}$  that satisfies the AMT- equation and the normalization condition  $\int \rho_{12} dV = 2$ . Since both electrons have the same energy  $E = eU$ , their states  $\rho_1$  and  $\rho_2$  correspond to sinusoidal wave functions  $\psi_1$  and  $\psi_2$  with a de Broglie wavelength equal to  $h/(2mE)^{1/2}$ . These functions satisfy the Schrodinger equation for a free electron, and it can be assumed that the state  $\rho_{12}$  of two electrons that have passed through the slits should be described as follows:

$$\rho_{12} = A(\psi_1 + \psi_2)^2 = A(\rho_1 + \rho_2 + 2\psi_1\psi_2)$$

Here the coefficient  $A$  must be determined from the normalization condition. The interference is given by a term  $2\psi_1\psi_2$  that is proportional to the  $\cos\Delta\psi$  where  $\Delta\psi$  is the phase difference between electrons, determined by the distance between the slits and the de Broglie wavelength [9]. That is, the substances of the interfering electrons are redistributed (but not mixed) in such a way that the maxima of their joint density determine the places of the most probable registration of the electrons in those places where their power action on the screen, proportional to the  $m\rho v^2/2$ , will be maximized.

The question is relevant: when and how does the electron "know" about its kinetic energy? When it is accelerated or when it is slowed down? Because during a uniform motion, by virtue of the principle of relativity, it must be insensitive to its motion. And there should be no waves in it, either

standing or running. I would like to think that the energy received by an electron due to the field acceleration enters in its structure during collisions: with an anode, with a collimator, with two slits. And after that all the redistribution processes take place, because the AMT-equation starts working.

If electrons encounter the crystal lattice of a substance under the action of an accelerating electric potential, then scattering should be expected when the antinodes of the electron density fall on the corresponding atoms of the crystal. And the nature of this dispersion explains the appearance of concentric circles on the photographic plate in the well-known classical experiment from 1927 [10, 11].

The representation of an electron as a charged "cloud" with spatial characteristics that change when electron goes from one stationary state to another allows us to interpret the concepts of elastic and inelastic collisions of an electron with an atom. These concepts are used to explain the classical Frank-Hertz experiment [12].

It should be noted that many quantum mechanical effects, which have been theoretically justified by the Schrödinger equation, have an adequate interpretation within the framework of the AMT-equation. In particular, the possibility of a particle passing through a potential barrier is due to the existence of positive solutions of equation (5) for  $E < U$ . The density of matter exponentially decreases within the barrier, and, depending on its width and height, can be nonzero inside and outside it. It can be assumed that the penetration of a material substance through a potential barrier is ensured by some special, "hidden" form of the internal energy of the particle, mathematically displayed by the first term of equation (5). This energy can be either positive or negative, making a corresponding negative contribution to equation (5). It exists only within the elementary particle and is due to the constancy of the immanent action. The integral of this energy over the volume of the particle is zero.

Well-known sodium and hydrogen doublets (hyperfine splitting) can be explained by assuming the presence of an intrinsic magnetic field in the atom. In the case of hydrogen, it can come from the presence of proton spin [13]. But in our understanding, there is no need to attract a spin-orbit interaction: it is sufficient that the rotating  $s$ -electron cloud reacts to the magnetic field of the proton.

### 3. On the Possible Mechanism of Photon Emission, Reflection, and Birefringence

Photon generation is undoubtedly the phenomenon of quantum physics. However, it can have classic "roots". Let's try to find them.

Indeed, if we assume that the dynamics of the material substance of the electron can be described by equation (4), then an increase in the electron energy by an amount  $\Delta E$  will lead to a redistribution of matter and charge density of the electron cloud in accordance with the equation:

$$\frac{h}{2} \frac{\partial \rho}{\partial t} + \frac{h^2}{4m} \nabla^2 \rho + (E + \Delta E) \rho - \frac{h^2}{8m\rho} (\nabla \rho)^2 - U \rho = 0 \quad (9)$$

In this case, an electron from a state  $\rho_0$  with energy  $E_0$  passes into a state  $\rho_1$  with energy  $E_0 + \Delta E$ . The electron cloud expands, changing the distribution of its charge both in space and in time, which in accordance with the classical Maxwell equations should lead to the emission of an electromagnetic wave.

Let us first evaluate the temporal characteristics of this process. We represent the density of matter  $\rho$  in the form of the product of two functions  $\rho = f(t)F$  :, where  $F$  depends only on spatial coordinates. After substituting in (9), we obtain two equations:

$$\begin{aligned} -\frac{h}{2} \frac{\partial f}{\partial t} - \Delta E f &= 0 \\ -EF - \frac{h^2}{4m} \nabla^2 F + \frac{h^2}{8mF} (\nabla F)^2 + UF &= 0 \end{aligned} \quad (10)$$

The second equation in (10) is the stationary AMT equation. The first equation gives a dependence  $f = \exp(-t/\tau)$  with a characteristic time  $\tau = h/2\Delta E$ . This is the transition time from level  $E_0$  to level  $E_0 + \Delta E$ . In this case, the electron cloud expands, radiating the first part of the electromagnetic pulse that takes energy  $\Delta E$  (or part of it). Deprived of additional energy, the electron cloud returns to its previous state  $\rho_0$  with the previous dimensions, radiating the second part of the electromagnetic pulse in a similar characteristic time  $h/2\Delta E$ . The total period of this cycle is  $2\tau = h/\Delta E$ . The corresponding frequency, if a similar process is repeated (energy is supplied from outside), will be equal to  $1/2\tau$ . And we get the classic  $\Delta E = h\nu$ .

Such a description of a photon has an advantage: a photon is represented as part of an electromagnetic wave, limited in space and time, a "link" in a pulse chain. Inside this wave, the magnitude of the electric field can vary widely, causing a different degree of exposure to the photon on the surface with which it collides, that provides the basis for visual observation of interference.

We are discussing the transition of an electron "cloud" from a low level to a high one after it received the additional energy  $\Delta E$ . A symmetric process with the same characteristic time should be expected in the reverse transition from a high to a low level if the energy  $\Delta E$  is extracted. This transition can be carried out, for example, if the second stationary state is unstable or does not exist at all. The electronic "cloud" will return to its former state, completing its elementary oscillation, during which the photon with energy  $\Delta E$  must be emitted. The first half-wave is emitted during the expansion of the "cloud" upon the transition of the atom to a higher energy level, the second half-cycle is emitted during the contraction of the cloud upon the return of the atom to the previous level. The whole period is equal to  $h/\Delta E$ . The inverse of this period gives the expecting frequency  $\nu$  of the

photon, and if the "pulsations" of the electron cloud are repeated (and this is possible, if the energy is fed from the outside all the time, for example, as a result of heating), so we get classical  $\Delta E = h\nu$ , and the radiating atom can work as a relaxation generator.

The foregoing description of the photon emission has the advantage: it represents a photon as a particle of an electromagnetic wave, limited in space and time. Within this particle-wave the field strength must change its amplitude and sign according to the first and second half-periods of the pulsation of the electron "cloud" which gives the basis for the interference of photons. Thus, the emission of a photon occurs in accordance with Maxwell's equations, and the electromagnetic impulses propagate at a speed of light  $c$  with respect to the nucleus around which the electron cloud pulsates.

Then, the reflection of light or its passage through a transparent medium can be interpreted as the absorption and re-emission of photons in the desired direction by atoms and molecules, respectively, from the mirror surface or in the volume of a transparent medium. The time required to absorb the photon energy by the electron cloud causes a delay of light and a decrease in its speed. And the duration of the electron cloud restructuring process, or rather its characteristic time, determines the wavelength of the photon.

The simple conclusion from the above is as follows. The light (photon) reflected from the mirror must always have a velocity  $c$  relative to the mirror, determined by the Maxwell equations, regardless of what speed it had before falling on the mirror. This theoretical fact explains the negative result of the Michelson-Morley experiment, in which several mirrors fixed relatively to the Earth were used. And anyway, any attempts to measure the speed of light (from terrestrial or extraterrestrial sources) using mirrors are always doomed to give a constant value of speed, which is in no way connected with the second postulate of Einstein's theory of relativity.

Thus, the processes of reemission of photons inside a substance or on its surface play the main role in the fact that the speed of light remains unchanged, since the photon, which received an additional speed of movement of the light source, after its reemission must again acquire the speed of light  $c$  relative to the surface or volume atoms. Consequently, in the experiments of Fizeau, Foucault and Michelson, the speed of light retains its constancy, since in these and other experiments the light either undergoes reflection, or passes through semi-transparent plates. Even deep space is not an object of absolute vacuum. It is filled with interstellar gas (possibly 90% hydrogen) in a very weak concentration, but sufficient for light to be repeatedly re-emit on its way from the star to Earth, and its speed becomes always equal  $c$ , which explains the absence of a paradoxical visual effect when observing binary stars.

Next, we discuss the process of photon generation and the estimated direction of its radiation. An electron in an atom, as is known, can be in different states depending on its internal energy:  $s$ ,  $p$ ,  $d$  and other states. For  $p$  and  $d$  states, the  $\rho$ -function (equal  $\psi^2$ ) has the corresponding form with a

pronounced axis of symmetry. Since, following the AMT-equation (9), the charged matter of an electron that has absorbed the energy  $\Delta E$  must be rearranged ( $\partial\rho/\partial t \neq 0$ ), we obviously receive electromagnetic wave radiation in full accordance with Maxwell's classical equations, namely, with his first equation ( $\text{grad}E = \rho/\epsilon_0$ ), as well as with the fourth. As for the direction of this radiation, it can be determined by the spin of the electron, the axis of its own rotation, along which the strongest changes in the electric field can occur during the spatial pulsation of the electron cloud. In 1925, Uhlenbeck and Goudsmit accepted the hypothesis of spin, assuming that the electron is similar to a rotating charged ball and must have an immanent mechanical and magnetic moment. But soon they actually abandoned their idea [14], because the electron (assuming its radius is of the order of  $10^{-15}$  m) will rotate with a superlight velocity. However, if we follow our concept and treat an electron as a charged cloud of the size corresponding to the spatial dimensions of the wave function of the Schrodinger equation, then the contradiction with the theory of relativity can be removed.

The rotation itself of a charged electron cloud (electron spin) should not cause photon radiation, since the charge distribution relative to the axis of rotation changes only when the energy content of the electronic substance changes. The spin of an electron turns it into an elementary magnet. It is easy to verify [6] that the gyromagnetic ratio for a cylindrical electron cloud with an axis of rotation is exactly the same as for a point electron in orbit, and is equal to  $e/2m$ . Imagine this cloud in a cylindrical coordinate system and split it along the axis of rotation  $z$  into flat disks of thickness  $dz$ . The module of the mechanical moment  $M$  of each disk will be equal to

$$M = dz \int m\phi 2\pi r v r dr = dz 2m\pi \int \phi v r^2 dr$$

where  $v$  is the azimuthal rotation speed of an elementary ring of radius  $r$ , width  $dr$  and mass density  $m\rho$ . The corresponding modulus of the magnetic moment of such a ring will be:

$$\mu = dz \int e\phi v \pi r^2 dr = dz e\pi \int \phi v r^2 dr$$

where  $e\rho v$  is the current density of the charged matter, enveloping the circle with the area  $\pi r^2$ . The gyromagnetic ratio  $\mu/M$  for these disks, as well as for the entire electron cloud, will be equal  $e/2m$ . We note that we have considered a fairly general case of rotation, not confining ourselves to "solid" rotation with a constant angular velocity.

So the two electron clouds rotating in one direction can form a stable structure of paired electrons in an atom, being attracted to each other by opposite magnetic poles. So, electrons in s-states can form a paired structure in the form of two hemispheres rotating in one direction. Such paired s-electrons are characteristic of the outer shell of metal atoms. They can provide a mirror reflection of a photon. In this case, the hemisphere facing the light source picks up (absorbs) the photon and radiates it back, since the radiation inside the

metal structure is blocked by the second hemisphere of paired electrons.

As for transparent substances, such as diamond, water, glass, the passage of photons through them can be ensured by unpaired p-electrons, which in these substances are on the outer shells of their atoms and molecules. These electron clouds, which have a dumbbell shape and an axis of rotation (they have a spin), can be considered as peculiar "tubes" along which the photon continues its movement (due to re-radiation) in the same direction or scatters in other directions.

If our assumption is true that the electron spin (more precisely, the axis of rotation of the electron cloud) can determine the direction of photon radiation, it becomes possible for photons to propagate in all directions (since the spin is randomly oriented). Continuous "chains" of photons actually create an analogue of a spherical wave, which Huygens wrote about in his work [15]. The envelope of this "wave" forms the leading edge of the beam when it is reflected or refracted.

Thus, a photon is a very peculiar "particle". It has neither mass nor charge. But it has a spatial extent (beginning and end), energy and polarization, which characterizes its internal electric field. And the speed of movement in space equal to the speed of light. Chains of unidirectional photons form a beam of light, the leading front of which coincides with its cross section. Experiments indicate that during its absorption a photon is able to lose part of its energy and give it to the electrons of the outer and inner shells of atoms of various substances (a phenomenological interpretation of the Compton effect we can see later).

Theoretically, both generation and the existence of a single photon are possible, but reality precludes this. However, the idea of a photon as a single particle facilitates the physical interpretation of a number of effects, in particular, birefringence. It occurs in all crystals whose syngonia is not cubic. The most striking form of birefringence is demonstrated by Icelandic spar, a crystalline form of calcite  $\text{CaCO}_3$ . The unit cell of the Icelandic spar is a parallelepiped, all six faces of which are parallelograms. In the nodes of the cell are calcium ions, and the complexes  $\text{CO}_3$ , according to scientists, are located in the middle of the edges of the unit cell. In these complexes, in the outer shells of carbon and oxygen atoms, there are several unpaired electrons in the  $p$ -state that are capable of emitting an absorbed photon. Let's choose any two opposite faces as the top and bottom. Then the complexes  $\text{CO}_3$  located above and below on each of the 4 lateral faces will be displaced relative to each other. If now a beam of light goes vertically perpendicular to the lower face, then the photons passing through the lower complex  $\text{CO}_3$  can be captured by the edge of the upper, displaced  $\text{CO}_3$ -complex, and after their absorption and re-emission can be inside the already displaced beam. These elementary shifts must be summed up as photons pass through the thickness of the crystal, and as a result, the primary beam is shifted by a noticeable distance. This beam is related to two opposite side faces. Two other faces provide the displacement of other photons. Thus, two

non-parallel beams are formed. Here it is appropriate to ask yourself: why is DOUBLE refraction, and not triple, quadruple, etc.? Yes, because there are only TWO pairs of opposite side faces in the unit cell, and the beams and the photons filling them differently move along them.

Let us now try to give our phenomenological interpretation to the Compton effect: an increase in the wavelength of an X-ray photon scattered on a solid sample. Suppose that a photon with energy  $E_1 = h\nu_1$  passing through a sample collides with an atom and is absorbed by its electron shell. The energy of the photon is somehow distributed between the electrons: a certain part  $\Delta E$  of it gets to an external electron, which is weakly bound to the nucleus, and it can leave its orbit, having received a corresponding momentum and kinetic energy from the photon. The energy  $E_2$  remaining in the atom equal to  $E_1 - \Delta E$  is concentrated in one of the internal electrons, whose cloud begins to rearrange its shape (expand) in accordance with the AMT equation (10). Since there is no corresponding stable stationary state for an atom with such energy, the electron cloud relaxes (contracts), returning to the previous energy level. Thus, a photon with energy  $E_2 = h\nu_2 \leq h\nu_1$  is emitted. The energy of the rebound electron depends on the nature of its collision with the photon: in the frontal collision, the electron momentum is collinear with the photon momentum, and the electron energy can be maximum, and the value  $E_2$  corresponding to the scattered photon will be minimum.

At the same time, some of the primary photons can be absorbed by the stable electron shells of already ionized atoms. They can also begin the process of excitation of internal electrons with the expansion of their electron clouds and subsequent relaxation - compression. The pulsation of these clouds comes with a characteristic time  $\tau \approx h / 2E_1$ , which leads to the re-emission (scattering) of photons with the initial energy and frequency and the appearance in the scattered spectrum of intense radiation with a primary wavelength.

Now we will discuss what possibilities our approach provides for the interpretation of laser emission. In lasers with a three-level pumping scheme, an atom from the excited state with energy  $E_1$  passes into the ground state with energy  $E_0$ : the corresponding photon is emitted due to the contraction of the electron cloud and redistribution of the electron charge from state  $e\rho_1$  to state  $e\rho_0$ . If this photon with energy  $(E_1 - E_0)$  is absorbed by some atom in the ground state, then the process of redistribution of the electron cloud from the state  $\rho_0$  to the state  $\rho_1$  with the corresponding generation of the first half-wave of the electromagnetic wave begins. Expansion of the cloud eats the absorbed energy, as a result, the electron cloud enters the state  $\rho_1$  without the necessary amount of energy and starts the transition back to the ground state  $\rho_0$ , generating the second half-wave of the electromagnetic wave. Thus, a high-grade photon with two half-periods of the wave is formed, which can provide constructive interference with other photons. We can assume that this is the photon of coherent radiation. The photon that emitted when the atom moves from level  $E_1$  to level  $E_0$

(spontaneous emission) should have only one half-wave, which excludes its interference with other photons. Perhaps this is the photon of incoherent radiation.

## 4. Conclusions

The paper shows the possibility of describing intra-atomic processes on the basis of ideas about the electron as a bulk particle with distributed material substance. On the basis of the Hamilton-Jacobi equation, a nonlinear differential AMT (Action-Matter-Transfer) equation is obtained that describes the dynamics in time and space of an electronic "cloud", that is, a charged substance of an electron. This equation allows us to give a classical interpretation of the photon generation process with a frequency and energy corresponding to the principles of quantum mechanics. A consistent physical picture of the semi-classical photon generation process is well-founded. The proposed AMT equation is genetically related to the Schrödinger equation, and density of the material substance of the electron is equal to the square of the wave function. The electronic "cloud", in addition to its charge and mass, should have the own axis of rotation and the moment of rotation (spin), which correspond to the experimental results. The proposed approach allows us to obtain an adequate explanation of the interference of both light and electron rays, however, it leaves no room for quantum superposition due to the significant nonlinearity of the AMT equation.

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