

1. Emission of Radiation by Atoms without the Energy Quantum Hypothesis

Abstract: The discrete emission spectrum of the hydrogen atom is described within a new variation principle of an open physical system in a finite range of space. Since the electromagnetic field is a non-conservative field the discrete spectra of atoms does not correspond to a quantization of the energy of the particle system and to the quantization of the electromagnetic field with photons. The difference compared with the Schrödinger eigenvalue problem will be considered. The excited atom is, within the Lagrange theory, only a part of the complete system and appears as “resonator” with discrete frequencies ν_{ij} . The oscillated charge density of the atom radiates classically electromagnetic waves with the wavelengths $\lambda_{ij} = c/\nu_{ij}$ and creates the discrete spectra in a finite space-time region. The wave nature of radiation dominates in the atomic emission processes because the wavelengths of the emitted rays are much greater than the sizes of the objects. The “light quantum hypothesis” of quantum mechanics is in our theory replaced with a new variation principle. Furthermore, as the variation principle describes not only bound states but also decaying ones of a system, we can e.g. consider the stable and the unstable particles in a unified way.

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Properties of the H Atom and its Spectra

The experimental observations with the hydrogen atom, on which our theory is based, are summarized first. The diameter of the hydrogen atom (H atom) is approximately 1 \AA ($=10^{-8} \text{ cm} = \text{Ångström}$). Depending on the physical

conditions of the environment of the excited H atom, one sees a finite number of N spectral lines. The number N of spectral lines becomes smaller if the excited H atoms are in dense gas; N becomes larger if the distance of the H atoms to the surrounding molecules is larger in the universe for instance. The wavelength of the observed emission is several thousand Å. The observed cut-off wavelength of the Lyman series is $\lambda_1 = 927 \text{ Å}$. For the Balmer, Paschen and Brackett series the cut-off wavelengths are $\lambda_2 = 3702 \text{ Å}$, $\lambda_3 = 8340 \text{ Å}$ and $\lambda_4 = 14870 \text{ Å}$, respectively. The cut-off wavelength of the Lyman series λ_1 is the smallest wavelength which plays a role in the emission or absorption of radiation by the hydrogen atom. However, the spatial extension of the H atom is roughly a thousand times smaller than the smallest wavelength of the emitted and/or absorbed radiation. The wavelength is thus not small in comparison with the size of the hydrogen atom (range of the medium). In this case we can not define the Eikonal equation of wave, where the wavelength should be small compared to the dimension of any change in the medium. Therefore a comparison of the Eikonal equation of the geometrical optics of the light (wave nature) with the mechanical Hamilton-Jacobi equation (corpuscular nature) for the principal function W (see Ref. [1], chapter IX) is not permitted. As the Eikonal theorem applies to the electromagnetic field too, we expect, in the case of the radiation process of the hydrogen atom that the wave character of the electromagnetic field dominates and the corpuscular nature can be neglected. Regarding this situation, from the duality of light – the Newton's light particle theory is equivalent to the Huygens's wave theory of light in the limit of geometrical optics (Hamilton, 1834) – we will decide in our theory against light particles against the photon hypothesis and favour the wave theory. We will describe the non-conservative electromagnetic fields classically with the Lagrange function of the system, L, i.e. we will describe the electric field \mathbf{E} and the magnetic field \mathbf{B} by a scalar potential ϕ and a vector potential \mathbf{A} .

As a complement to the emission quantities of the excited H atom, we may mention the exponential behaviour of the intensity of emitted radiation through the radiating atom. The radiation time is in the range of 10^{-8} sec. The length of the coherent wave train is also measured in meters.

After these considerations, we can state that for a second analysis in the "quantum chemistry", the usage of the classic electromagnetic fields is appropriate for all atoms and molecules. In order to explain radiation phenomena and chemical reactions the conditions are similar to for the hydrogen atom. Then, in the most extreme case of atoms with $Z = 100$ nucleus charge, the diameter of the $(Z-1)$ times ionized atom ground state is approximately 10^{-2} Å and the cut-off wavelength of radiation is $\lambda_1 = 10^{-1}$ Å. Thus, also in this case, we are not in the limit of geometrical optics and the wave nature of radiation dominates. This means that the validity of classical electrodynamics has to be extended to all atomic systems without consideration whether the atomic systems, the electrons, is treated as a non-relativistic or as a relativistic system.

In order to describe the Lagrangian of the atomic systems we turn to the terms describing the charged particles and the interaction of an electromagnetic field with charged particles. At first we need the wave function of the latter.

The Electron Wave

First, the electron will be examined. Considering the arguments above regarding the form of the wave equation for particles, for which the mechanical Hamilton-Jacobi equations represent the limiting case of short wavelengths, a proportionality of the particle energy E and the wave frequency ν must exist, see

Ref. [1], Chapter IX. This proportionality constant h is the famous Planck's constant, Ref. [2]

$$E = h \nu. \tag{1}$$

However, this equation is by no means a quantization of the energy. As the relation between the wavelength of the particle λ and the frequency is set to be $\lambda \nu = u$, where u is the wave velocity of the "material wave", the equation

$$\lambda = u / \nu = (E / p) / (E / h),$$

gives the relationship between λ and p . Therefore the amount of the momentum of the particle and λ holds

$$\lambda = h / p. \tag{2}$$

The wave velocity of the "material wave" u for a particle system is identical to the wave velocity of the S areas, where S is the Hamilton action function, and the following applies. This is essential at least for non-relativistic particles. In the relativistic case of particles the relations Eqs. (1) and (2) should be re-investigated carefully,

$$u = E / \sqrt{2m(E - V)} = E / \sqrt{2mT} = E / p,$$

whereby V is the potential and T the kinetic energy of the particle. This is used to derive Eq. (2).

Furthermore, in analogy to the time-independent wave equation of optics

$$\nabla^2 \Phi + (4 \pi^2) / \lambda^2 \Phi = 0,$$

there must be a quantity ψ for the particle waves, corresponding to the wave amplitude Φ of the optics. It must satisfy the equation with the wavelength

$$\lambda = h / p = h / \sqrt{2m(E - V)}. \quad (2')$$

Consequently, the time-independent wave equation of mechanics, for which the principal function W represents the Eikonal, must be

$$\nabla^2 \psi + (8 \pi^2 m / h^2) (E - V) \psi = 0. \quad (3')$$

In Eq. (3') we recognize the time-independent Schrödinger equation in Ref. [3] for the electron wave function defined by de Broglie in Ref. [4]. We have recalled the Eqs. (1) – (3') here for the purpose of embedding the Planck's constant into the Lagrange formalism. We can do it as follows: h applies only to the wave functions of the particles in the Lagrange formalism for continuous systems and not also for the electromagnetic field.

At this stage we can not decide if the introduction of the classical fields for the electromagnetic interaction in the Lagrange function is justified for all physical systems. But also in the case of nuclei the situation seems to be similar to the case of atomic systems because the size of nuclei ($\approx 10^{-13}$ cm) hundred times smaller as the characteristic wavelengths of γ - decays 10^{-11} cm.

At very high energies and at very small length scales in material medium. (E.g. for the quarks, but what are quarks and what is their size?) the radiation particles (photons) could play a role in the elementary processes, but a new consideration must then be given to Eqs. (1) and (2). The proportionality factor between energy and frequency of the photons does not have to be the Planck's constant a priori. In this case we will go into the opposite direction: from the wave property of the

electromagnetic field to the corpuscular nature of radiation. That is, we would use the geometrical optics approach with a photon picture. In the very small length scales of quarks the question would be arise whether fundamental physical processes produce the photons at those very high energies?

After these initial considerations on the electromagnetic field and on particle wave functions, we turn now to the Lagrange formalism which will be used for continuous systems and fields, see Ref. [1]. Our non-relativistic system of material consists of an electron and a proton, which interacts with the classical electromagnetic field. As mentioned above, the Planck's constant h should only be included in the wave function of particles ψ in the Lagrange function, that is we have forgone the fundamental photon hypothesis of Einstein, Ref. [13] in our theory.

The construction of Lagrange functions L for those continuous systems is subject to strict rules. The generalized coordinates of the fields (here ϕ , \mathbf{A} , and ψ 's) are included in the theory via the Lagrange density and possible terms can only contain the first derivatives according to space and time of the generalized coordinates. In addition, the construction of L must fulfil conditions of invariance.

We have chosen the Lagrangian of the system because it is more general as the Hamiltonian.

The Lagrangian of the Hydrogen Atom and of the Electromagnetic Field

In setting up the Lagrange function of our system we ignore the magnetic momentum of the proton and the electron. Likewise, we do without the effects which would arise from relativistic treatment. These influences will be followed up in later publications. In the present approximation only the Coulomb field

(two body central potential problem) is left for the interaction between proton and electron and the movement of the mass centre \mathbf{R} can be separated in the Lagrange function. This leaves an equivalent one body problem for the relative motion \mathbf{r} of the electron in the Coulomb field of the proton with the reduced mass

$$\mu = (m_p m_e) / (m_p + m_e).$$

The movement of the mass center can be considered as constant. As the mass of the proton m_p is larger by around the factor 1836 than the mass of the electron m_e and therefore, following Eq. (2'), the wavelength of the proton λ_p against λ_e is small at the same energy, we treat the proton only as a point particle and limit ourselves to the wave function of the electron and the electromagnetic field in the Lagrange function. The large value of m_p allows identifying \mathbf{R} with the location of the proton in good approximation. The fields in the Lagrangian are therefore described in a special inertial system which moves with the centre of mass and the local coordinates are $\mathbf{r} = (x,y,z)$.

To obtain simpler expressions, we will also give the energy in units of $h^2 / (8\pi^2 \mu)$, i.e. we will divide the Lagrange function and the Lagrange density L by this factor. The time-independent Schrödinger equation is in this "energy unit"

$$\nabla^2 \psi + (E - V) \psi = 0. \tag{3}$$

We use the wave function of the electron ψ to formulate the Lagrange function of the electron moving in the Coulomb field of the proton. The electromagnetic field is described by the scalar potential

$$V = -q \phi ,$$

where q is the electron charge and by the vector potential \mathbf{A} . As it is described in Ref. [1], about continuous systems and fields, the Lagrange function can be put together additively from several terms. These additive parts of the Lagrange function consist of volume integrals via the Lagrange density L . The L itself consists of the kinetic energy of the electron L_T , of the part that stands for the interaction between the charged particle and the electromagnetic field L_i , of the part of the electromagnetic field itself without charge and electrical current L_{em} and of a part L_d which is required to derive the dynamic equation of ψ and contains the time derivative $d\psi/dt$.

The complete Lagrange density for the Lagrange function is

$$L = L_T + L_i + L_{em} + L_d. \quad (4)$$

We choose the Lagrange density for L_T , so as Schrödinger has chosen

$$L_T = \nabla\psi^* \cdot \nabla\psi. \quad (5)$$

Since the electron carries only a charge $-q$, the Lagrange density for L_i is

$$L_i = -q \phi \psi^* \psi + \mathbf{j} \cdot \mathbf{A} / c = -\nabla\psi^* \psi + \mathbf{j} \cdot \mathbf{A} / c, \quad (6)$$

whereby the current density \mathbf{j} is produced from ψ

$$\mathbf{j} = i q / 2 m (\nabla\psi^* \cdot \psi - \psi^* \cdot \nabla\psi). \quad (6')$$

The Lagrange density for L_{em} is

$$L_{em} = (E^2 - B^2) / 8 \pi. \quad (7)$$

We remember that the electromagnetic fields (\mathbf{E} , \mathbf{B} , ϕ and \mathbf{A}) should also be included in our "energy units".

About the construction of L_d it can be said so far that taking the approach

$$L_d = i 4 \pi m / h (\psi^* d\psi/dt - d\psi^*/dt \psi), \quad (8)$$

the time-dependent dynamic equation for the generalized coordinates ψ^* and ψ is generated if one leaves out the current density dependent part of L_i . This arises in the context of functional derivatives of the Lagrange density L with respect to the generalized coordinates ψ^* and ψ , through the Lagrange equations. However, the dynamic equation of the electron is of no relevance in this paper. The Maxwell equations arise from the variation of L according to the generalized coordinates ϕ and \mathbf{A} .

We can write the Lagrange function of the system as a volume integral via the Lagrange density L

$$L = \int \{ \nabla\psi^* \cdot \nabla\psi + V \psi^*\psi + L_{rem} \} dV, \quad (9)$$

in which all remaining terms not listed explicitly in Gl (9) are included in L_{rem} . The fields appearing in the Lagrange density are functions of the local coordinates $\mathbf{r} = (x, y, z)$ and the time t .

Now let us turn to the integral

$$\mathbf{I} = \int \{ \nabla\psi^* \cdot \nabla\psi + V \psi^*\psi \} dV, \quad (10)$$

and split the integral to be carried out over the entire space into an integral \mathbf{I}_1 with $r \leq D$ and the remainder for $r > D$.

We would like to put forward a new variation principle in respect of the first integral \mathbf{I}_1 in a spherical volume with the finite radius D and at a fixed time t .

The New Variation Principle and Eigenvalue Problem

The new variation principle will be formulated as:

The functions ψ^* and ψ are being sought which produce an extreme value for the two integrals \mathbf{I}_1 and \mathbf{I}_2 . They will be integrated in a spherical volume with a finite radius D , namely

$$\mathbf{I}_1 = \int_{r \leq D} \{ \nabla \psi^* \nabla \psi + V \psi^* \psi \} dV, \quad \text{extreme value,} \quad (11)$$

and

$$\mathbf{I}_2 = \int_{r \leq D} \{ \psi^* \psi \} dV, \quad \text{extreme value,} \quad (12)$$

The subsidiary condition is that the integral over $\psi^* \psi$ on the spherical surface is a constant which is not 0. During the variation procedure we also want to permit the variation at the integration border, i.e. at the instead $r = D$

$$\delta \mathbf{I}_i = \mathbf{I}_i (\psi^* + \delta \psi^*, \psi^* + \delta \psi^*, D + \delta D), \quad (13)$$

for $i = 1$ and 2 . The functions ψ^* and ψ should to be treated as independent quantities.

As earlier researched by Szász in Refs. [5], [6] and [7] have shown, such a variation principle leads to an eigenvalue problem with two eigenvalue parameters ε and κ . If \mathbf{I}_1 and \mathbf{I}_2 have an extreme value then the linear combination $\mathbf{I}_1 + \varepsilon \mathbf{I}_2$ has also an extreme value. The second parameter occurs the by reason of the subsidiary condition. Because of the permitted variation at the integration borders, the relation

$$\varepsilon = -\kappa^2, \quad (14)$$

must be between the two eigenvalues. The accompanying differential equation is

$$\nabla^2 \psi + (\varepsilon - V) \psi = 0, \quad \text{for } r \leq D, \quad (15)$$

and for the stationary functions ψ there is a "natural boundary" condition for a large D

$$\psi' - i \kappa \psi = 0, \quad \text{for } r = D \quad (16)$$

The stationary function ψ^* fulfils the complex conjugate of Eqs. (14) – (16).

The derivative of ψ in Eq. (16) is

$$\psi' = \mathbf{n} \cdot \nabla \psi,$$

the derivative in direction of the normal \mathbf{n} on the spherical surface. Expressed in spherical coordinates (r , θ and φ) and with the product Ansatz

$$\psi(\mathbf{r}) = u(r) Y(\vartheta, \varphi),$$

this means

$$u'(r) = 1/r d(r u(r))/dr$$

for the radial part $u(r)$.

The variation principle has to be taken for a fixed time t . This variation principle must not be mistaken for the variation of the Lagrange function according to generalized coordinates.

The numerical calculations in Refs. [8] and [9] show that the variation principle can be used explicitly to describe bound states and "decaying states" of a system. So we are able to calculate the stationary functions and the discrete eigenvalues of the parameters ε and κ , E_i and k_i . The eigenvalues, E_i , are for bound state negative, with $\text{Re } k_i = 0$ and $\text{Im } k_i > 0$, and for decaying states they are complex with a positive real part of k_i ($\text{Re } k_i > 0$) and negative imaginary part of k_i ($\text{Im } k_i < 0$). The variation principle produces a none expected new relation between the Lagrange theory and poles of the scattering matrix.

Historically, this variation principle originated from the need to describe the quantum mechanical "unstable state" in a systematic manner. The search for a consistent description of unstable systems was also considered necessary when the SU3 symmetry in the strong interaction of the "elementary" particles was examined by Szász in Ref. [10]. During relations between mass and life times of extremely short-lived elementary particles could be derived, the comparison with experimental data was unsatisfactory. The properties of unstable "elementary" particles were taken painstakingly from the resonances of the scattering cross sections. Hereby, the criterion what determines the "resonances" was not specified precisely. It was impossible to answer the question as to the nature of "unstable states" within quantum theories. Therefore, we had to return to quite fundamental things observation of which left its mark on modern physics in the last century. On the other hand, in the last 30 years the success of the SU3 symmetry led to the quark theory of "elementary" particles.

The question now arising is have we understood the fundamental processes described in "quantum physics" correctly? Or is there something that distorts our view of the basic processes? Is the quantization of energy really needed? Or is it a working hypothesis, until we have a better understanding of the elementary processes? Are the fundamental difficulties in quantum field theories (i.e. in

quantum electrodynamics) not a hint to strive for a deeper understanding? Is the fundamental hypothesis of the quantum theory, i.e. the “quantum hypothesis” of photons with discrete energy, really needed in order to describe the physical phenomena? What did really happen in the fundamental physical experiments on atomic systems at the beginning of the last century?

Comparison with the Schrödinger Variation

We look at this question and put our variation principle in relation to the Schrödinger variation calculation in Ref. [3]. There the integrals (11) and (12) are considered over infinity ($D = \infty$), whereby the extreme value (11) is sought on the subsidiary condition that the integral (12) is constant. This leads to an eigenvalue problem with only one parameter E , which is interpreted as energy. The differential equation (15) applies here to all \mathbf{r} . The boundary condition Eq. (16) is also met by all the stationary solutions of the Schrödinger equation in the limit $D \rightarrow \infty$. This condition corresponds to the boundary condition for a “outgoing wave”. Discrete eigenvalues of the Schrödinger eigenvalue problem exists only for negative values E_i (energy eigenvalues), i.e. the k_i are purely imaginary with a positive imaginary part

$$\text{Im}k_i = i \sqrt{-E_i} .$$

It can be concluded that the first N stationary solutions of the Schrödinger equation, which energetically are the lowest ones, are also in good approximation a solutions of our variation principle if we choose a sufficiently large D . The numerical calculations by Ramaglia and Zucchelli in Ref. [9] seem to confirm this. A measure of the deviation of the eigenvalues in both methods

$\Delta E = E_i - E_j$ is an integral of r , from D to ∞ , over the far-reaching Coulomb potential, multiplied by an exponential function $\exp(-2 \text{Im} k_i r)$.

We can thus also take the well known first N wave functions and the eigenvalues of the Schrödinger equation approximately as stationary solutions of our variation principle too, but we cannot interpret the eigenvalues E_i a priori as energies.

The numerical calculations by Ramaglia and Zucchelli in Ref. [9] show a peculiarity of the new variation principle: With far-reaching potentials there is, depending on the choice of D , a varying number of stationary solutions. That is exactly what is observed with the hydrogen atoms in gases at various densities. However, the stationary solutions for the first N eigenvalues seem practically do not depend on the choice of D , provided D is sufficiently large. This property of the stationary solution of the variation principles and the corresponding eigenvalue problem should be treated very careful mathematically. The mathematician would be asked for help to clearing this problem: There are existence theorems needed for stationary solutions by general interactions. In the case of numerical calculations, there are convergence criterions relevant. Approaches to other well known eigenvalue problems, as the Schrödinger one, are also very useful at least for N stationary solutions.

The Excitation of the Hydrogen Atom

Stationary solutions of Eqs. (11) – (13) should give the time dependence of the corresponding stationary functions in the conventional units for energy

$$\psi_{E_i}(\mathbf{r},t) = \psi_{E_i}(\mathbf{r}) \cdot \exp(-i E_i t 2\pi/h). \quad (17)$$

This would result in a charge density that is constant in time. The time-independence of the charge density holds only in the ground state of the H atom, however. The ground state corresponds with the lowest eigenvalue E_1 , of Eq. (15). In this case we can imagine that the interaction of the H atom with an external electromagnetic field is absent in the whole space. The term L_{rem} in Eq. (9) can then be completely ignored and we can also use the limit $D \rightarrow \infty$. The hydrogen atom does not radiate in its ground state ψ_{E_1} because the location probability of the electron

$$\rho(\mathbf{r},t) = \psi_{E_1}^*(\mathbf{r},t) \cdot \psi_{E_1}(\mathbf{r},t)$$

is time independent

$$\psi_{E_1}^*(\mathbf{r},t) \cdot \psi_{E_1}(\mathbf{r},t) = \psi_{E_1}^*(\mathbf{r}) \cdot \psi_{E_1}(\mathbf{r}), \quad (18)$$

and E_1 can indeed be considered as the energy of the ground state.

If the H atom is excited by an excitation wave package, schematically shown in Fig. 1, the atom changes to the excitation state

$$\psi(\mathbf{r},t) = \sum_i a_i \psi_{E_i}(\mathbf{r},t), \quad (19)$$

which reflects a superposition of N stationary functions of different E_i , with that of E_1 . The summation has to be performed over a finite number of eigenfunctions. We neglect the degeneration of eigenvalues E_i and use Eq. (19) for simplicity.

The charge density of the electron in the excited state is

$$-q \rho(\mathbf{r},t) = -q \sum_k \sum_i a_k^* \psi_{E_k}^*(\mathbf{r},t) \cdot a_i \psi_{E_i}(\mathbf{r},t)$$

$$= -q \sum_k \sum_i a_k^* a_i \psi_{E_k}^*(\mathbf{r}) \psi_{E_i}(\mathbf{r}) \exp(-i(E_i - E_k)t / \hbar), \quad (20)$$

because of Eq. (17). This gives an oscillating charge density of a “resonator” with the frequencies

$$\nu_{ki} = (E_k - E_i) / \hbar, \quad (21)$$

which sends out electromagnetic waves with these frequencies, according to the Maxwell equations.

Fig. 1. The figure shows schematically the hydrogen atom excitation process before ($t < 0$), during ($t = 0$) and after ($t > 0$) the excitation where $\rho(\mathbf{r})$ is the electron location probability and $A(\mathbf{r})$ is the amplitude of the classic electromagnetic field. After the excitation, the charge density $q\rho(\mathbf{r},t)$ of the excited H atom oscillates and emits waves with discrete frequencies ν_{ki} on the rear flank (in a finite space-time region) of the excitation wave package. In this space region marked with \downarrow the exponential behaviour of emitted wave appears and in this region the limited radius D of the variation principle should be selected.

The time evolution of the excitation is shown schematically in **Fig.1**. This Figure shows that the spectral lines

$$\lambda_{ki} = c / \nu_{ki},$$

can only be observed on the rear flank (in a finite space region) of the excitation wave package. The intensity of the radiation decreases exponentially in this area and the H atom returns progressively to its ground state because of radiation losses.

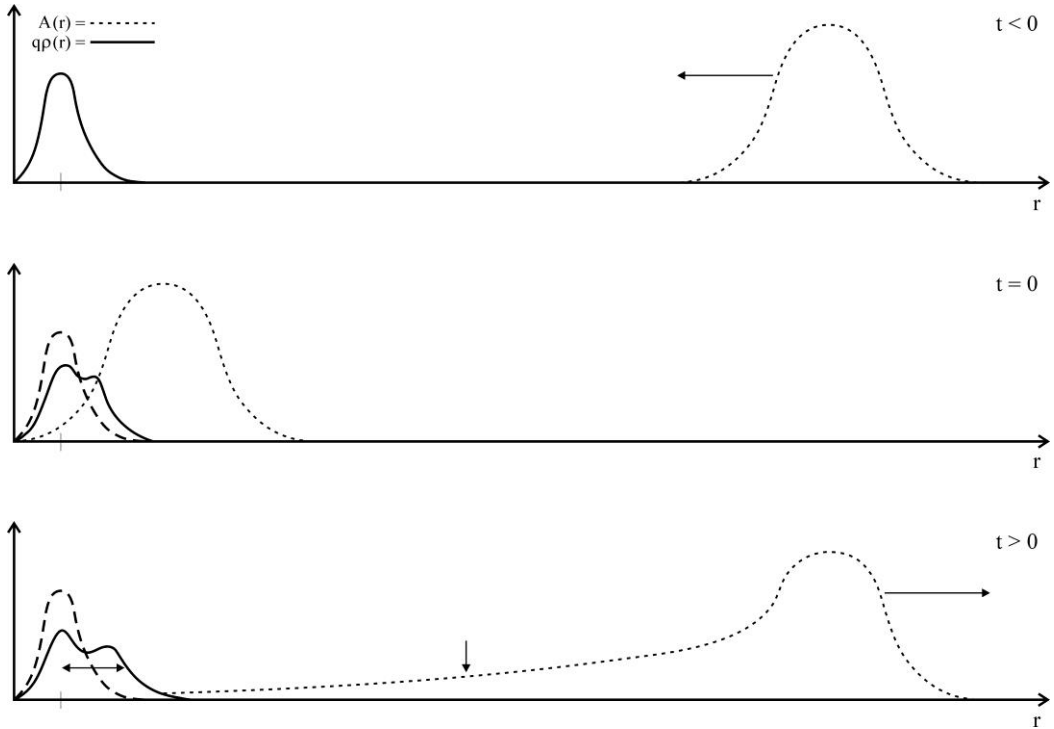


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The H atom behaves like a "resonator" with discrete frequencies. Going from its ground state, the H atom can continuously absorb energy from the electromagnetic field during the excitation, depending on the offered excitation spectrum. After the excitation, due to radiation losses, the energy of the electron decreases continuously. However, the H atom filters only discrete frequencies from the offered spectrum (absorption) due to its natural oscillator frequencies

ν_{ki} . If all the offered frequencies are lower than the first natural frequency of the „resonator“ ν_{21} , then no frequencies can be absorbed. This is what is seen, in principle, in the Franck-Hertz experiment, Ref. [11], where a minimum of electron energy,

$$E_{el} = 4,9 \text{ eV},$$

is needed for the excitation of mercury vapour and the first resonance line of the mercury atom of is at the frequency

$$\nu_{21} = 4,9 \text{ eV } 2\pi / h.$$

Further Consequences

Lénard's observation, Ref. [12], of the threshold value of the frequency within the photoelectric effect becomes also clear, in principle. A minimum frequency ν_g is required to release the electrons. The electron cannot store energy at frequencies below ν_g due to the loss of radiation. If the frequency of the radiation exceeds ν_g then the electron has a chance of being released. The findings of Lénard and Millikan of the effect that the maximum energy of the released electron depends on the frequency of the light, can be explained at least qualitatively: The time dependency of the electron wave function, if the electron is considered as free, could be propitiously to the one of the electromagnetic radiation. However, since the electron however is not free inside the atom (or in the metal), the energy is to be reduced by the release energy. So is, according to Eq. (2), also its frequency. It should be mentioned here that Millikan took very exact measurements of h from the photoelectric effect because he did not want to give up the wave theory of radiation. According to these findings, the light quantum hypothesis of Einstein, Ref. [13], would not only be dispensable for the

explanation of the photoelectric effect, but also for the explanation of the line spectrum of the H atom for the Franck-Hertz experiment, Ref. [11].

Our theory has the advantage over the light quantum hypothesis, that the "transitional probabilities" can be calculated also according to Eq. (20), which is impossible with the photon hypothesis. In addition, we can imagine the excitation of the atom in space and time, which is also not possible with the photons. The complete Lagrange function can be constructed in our theory, as it is demonstrated, without quantization of the electromagnetic field.

The relativity theory and the light quantum hypothesis are strictly speaking contradictory since in the infinitely short time the "quantum state" of the electron, i.e. the wave function of it, must change in the whole space, yet the electron has a finite mass. However, it should be remembered that in the year 1905 physical ideas about the elementary processes in atomic area were just beginning to emerge.

The re-explanation of Planck's radiation formula, Ref. [1] and of Compton effect, Ref. [14], seems not to present a major problem in our theory, where there are no photons. Owing to the lack of space in this paper they will not be explained here. The re-explanation of the effect of the magnetic moment of the electron on the spectra and in the Stern-Gerlach experiment in Ref. [15] also waits to be calculated. Furthermore we plan to provide an extension of our theory for multiple body problems and the relativistic formulation. It is known that the Schrödinger eigenvalue problem fails in the Helium atom spectra.

However, the question arises how can the observed phenomena that the radiation wave appears sometimes as a discrete process be explained, i.e. in the coincidence measurement of the Compton scattering. The answer would be that

the radiation interacts with a discrete material structure, also with an atom, and it is this, what we observe.

After a careful performed revision of the fundamental concepts in physics, we will finally return to the physics of the fundamental processes of “elementary” particles, which is where we started from Ref. [10] and why the new variation problem has arisen. We will then treat the stable and unstable particle as well as the bounded nuclei and the radioactive nuclei with the same variation principle in a unified way within the Lagrange formalism.

A New Variation Principle Instead of the “Energy Quantum Hypothesis”

At this point some remarks about the new variation principle: The requirement of the second extreme value Eq. (12) means that the stationary solutions of the variation principle turn the location probability of particles in the interaction range into an extreme value. The fulfilment of the natural boundary condition, Eq. (16), depends only on the interaction within the spherical volume and replaces a mathematically based boundary condition ($D = \infty$). The bounded states and the decaying states of a system can be treated simultaneously with the variation principle.

The eigenvalue problem Eqs. (14) – (16) in the context of this variation principle is new to mathematics especially since the natural boundary condition Eq. (16) includes the eigenvalue. However, the variation principle can be easily used to solve approximately the problem for stationary functions by numerical techniques, as shown in Refs. [8] and [9]. The eigenvalue problem is not a Hilbert space problem. The variation principle and the resulting eigenvalue problem refer to a subsystem of a completed system in the Lagrange theory.

The excited atom appears as a "resonator" and radiates with its oscillating charge density via the Maxwell theory. It produces discrete spectra in a finite space region. We have a hint that photons play no part in the emission or absorption of radiation by the atoms. Therefore, the relations in Eqs. (1) and (2) for photons (the proportionality of the energy and frequency $E = h \nu$ and the relation between momentum and wave length $\lambda = h / p$) should be considered very carefully as physical "reality". The Planck's constant h does not lead to an "energy quantum" in atomic physics. There is no need to for the quantization of the electromagnetic field (of quantum electrodynamics) in order to understand the absorption/emission of radiation by atoms if we use the new variation principle instead of the energy quantum hypothesis of light.

The far reaching consequences of these statements will be discussed in following papers in which we replace the most famous hypothesis of the quantum theory with the new variation principle. The atomic processes will then be explained without any further hypothesis. After a revision of the fundamental physical concepts, we will describe the stable nucleus state and nucleus decays as well as the stable and unstable particles as stationary solution of the new variation principle.

Conclusions

The wave nature of radiation dominates in atomic processes because the approximation, which leads to the Eikonal equation of geometrical optics, but does not apply to waves- radiation there. Within the Lagrange theory a new variation principle describes the physically observed phenomena of discrete spectra of atoms. In the atomic processes only the appearance of h in the wave functions of particles is responsible for all the observed phenomena. This is not a

quantization of energy. The quantization of the electromagnetic field is not needed in this area. The fundamental axioms of physics and the elementary processes should be discussed and evaluated in this new context. This will lead to the treatment of the stable and decaying nucleus in the same manner as the stable and unstable particle as stationary solution of the variation principle.

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The dates of the most important experiments and theories of the “quantum physics” and their acceptance have been listed in order to demonstrate the chronological developments in atomic physics.

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