Derivation of the Lamb shift with due account of wave features for the proton-electron interaction

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Abstract: *We regard the hydrogen atom as a pulsing spherical-cylindrical wave system to which the three-dimensional wave equation is valid. On this basis, taking into account radial pulsations of the spherical shell of a proton, we arrive at a zero level (background) spectrum of the hydrogen atom. The background spectrum obtained contains the term corresponding to the 2.728 K temperature that is the characteristic value for "relict" background measured by NASA's Cosmic Background Explorer (COBE) satellite. The frequency gaps 8172.852 MHz and 1057.8447 MHz between the nearest background terms among all calculated almost coincide with the most accurate experimental values available for the 1S and 2S Lamb shifts.*
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Key words: *atomic spectra, background radiation, Lamb shift, hydrogen atom, electron's properties, fundamental constants, zero point energy*

Resumo: *Consideramos o átomo de hidrogênio como um sistema de onda esférica-cilíndrica pulsante, para o qual a equação de onda tridimensional é válida. Partindo deste princípio, levando em conta pulsações radiais da casca esférica de um próton, nós chagamos ao espectro de nível zero (fundo) do átomo de hidrogênio. O espectro de fundo obtido contém o termo correspondente à temperatura de 2,728 K que é o valor característico para o fundo medido pelo satélite Explorador de Fundo Cósmico (COBE -Cosmic Background Explorer) da NASA. A freqüencia tem uma lacuna de 8172,852 MHz e 1057.8447 MHz entre os termos de fundo mais próximos, dentre todos os calculados, e quase coincide com os valores experimentais mais exatosdisponíveis para os deslocamentos da Lamb 1S e 2S.*

Palavras-chave: *espcetro atômico, radiação de fundo, deslocamento de Lamb, átomo de hidrogênio, propriedade dos elétrons, constantes fundamentais, energia de ponto zero*

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1 Introduction

An electron orbiting a proton in the hydrogen atom experiences a slight energy shift. The latter was first found by W. Houston, in 1937 [1], and then measured with high precision in 1947 by W. Lamb and R. Retherford [2]. According to the theory of quantum electrodynamics (QED), the shift is a result of the interaction between an orbiting electron and the teeming virtual particles residing in the surrounding vacuum.

Due to fluctuations of the zero field of vacuum, the orbital motion of the electron in an atom is affected to the additional chaotic motion. The main constituents of the energy "splitting", called the Lamb shift, are the effects of vacuum polarization, electron mass renormalization and anomalous magnetic moment.

QED apart, other departments of physics, in the framework of existed theories of atoms and elementary particles, are unable to explain the Lamb shift. Therefore, the precise derivation of the Lamb shift carried out by QED is currently regarded as the most stringent test of the validity of the QED theory.

Despite of the first and subsequent relatively fortunate calculations made with QED, which was initially developed to explain just the Lamb shift in the hydrogen atom, "It is...far from clear that everything is okay with QED" [3]. Sharing this opinion, we assume that not all possible elementary wave processes were taken into account to explain this phenomenon. In particular, the specific wave processes running inside nucleons and electrons, and between these particles coupled in atoms, were not yet properly examined.

In the first works in this direction published quite recently, in 2001 [4, 5], the unknown earlier wave behavior of elementary particles and intra-atomic wave processes were taken into account. As a result, the *Dynamic Model of Elementary Particles* (DM) was developed. On the basis of the DM, the unknown earlier nature of some fundamental physical quantities and constants was revealed. First of all, it concerns the origin of mass and charge of elementary particles. Many others interesting results were obtained after understanding the crucial role of the specific wave structure and wave behavior ascribed to elementary particles in the framework of the new model.

The DM gives the first opportunity to explain the Lamb shift from a new point of view by fully developed methods of wave physics, beyond QED. According to the DM, a center of mass of a proton and its so-called wave shell are affected by proper wave influence (owing to the wave structure and behavior of the proton according to the definition). Therefore, they constantly oscillate with the definite frequency and amplitude; in the state of equilibrium as well. Disturbing the electron's orbiting on the frequency of wave exchange, different from the frequency of orbiting, they cause natural background oscillations of an electron in the hydrogen atom on this frequency. This process was examined theoretically and proved to be valid, being in conformity with evidences, that is described first in [6].

Thus, the natural (unceasing) intra-atomic oscillations influence the orbiting electron and form the spectrum of zero level (background) radiation. The background radiation spectral formula for the hydrogen atom was obtained in the work [6] on the basis of radial solutions to the wave equation in spherical (for the proton) and cylindrical (for the orbiting electron) coordinates. The one spectral line of the background spectrum, corresponding to the 2.7 K temperature, was only calculated and presented there.

In this paper, for the first time, continuing the work [6], we compute the first ten (major) spectral terms of the background spectrum. The computation is carried out on the basis of the formula of the background spectrum which was defined more accurately as compare with that one first presented in [6].

We also use here the current "CODATA recommended values" for fundamental physical constants. An analysis of the spectrum obtained, indicates that the energetic difference between the nearest terms corresponds in value to the 1S and 2S Lamb shifts.

The data shows thus that cosmic microwave background radiation (CMB) of the top temperature of 2.7 K and the Lamb shift both have the same source of their origination; both phenomena reflect the unit process. They reveal the different elementary parameters of the background spectrum of the hydrogen atom: energetic structure (wavelengths and frequences) of spectral terms of the background radiation of hydrogen (detected in Cosmos just because of the immense abundance of hydrogen there) and the frequency (energetic) gaps between these terms (detected at the atomic level as the Lamb shifts).

The results obtained call in questions the Big Bang hypothesis of the CMB origin, regarded by the majority as a "relict" background radiation left after Big Bang, and the QED concept of "virtual" particles introduced first for the explanation of Lamb shifts (and the anomalous magnetic moment of an electron).

For understanding the matter in question, we recall concisely in the next section o few of the principal notions which belong to the realm of the DM [5]. Further, we will show the main steps which lead to the unknown earlier generalized spectral formula for the hydrogen atom [6], expressed for the first time by roots of Bessel functions. Then, on the basis of the above considered, we will proceed to the final stage of the paper - the derivation of the refined hydrogen atom background spectrum. The nature of the Lamb shifts will be clear visible from the presented differences of the terms obtained.

2 The dynamic model of elementary particles; main definitions

The hydrogen atom is a simplest paired centrally symmetric proton-electron system. According to the DM, the hydrogen atom is also a pure *wave* dynamic formation.

It means that a proton, just like an electron or any elementary particle, is in a state of continuous dynamic exchange (equilibrium) with environment through the wave process of the definite unchanged frequency ω (recalling a micropulsar). From the above definition it follows that elementary particles of the Dynamic Model, being unceasingly pulsing microobjects, can be regarded as inexhaustible sources of the so-called zero point energy.

A pulsing spherical wave shell of a proton (and of an electron) separates its inner space from ambient wave fields. The shell restricts the main part (core) of the particle from its field part merging gradually with the ambient field of matter-space-time.

Longitudinal oscillations of the spherical wave shell of the proton provide an interaction in radial direction (more correctly *exchange* of matter-space and motion-rest [5]) with the surrounding field-space and with the orbiting electron.

The orbital motion of the electron is associated with the transversal *cylindrical* wave field. Therefore, the common three- dimensional wave equation is valid for both cases. Both dynamic constituents of the proton- electron system have to be described, respectively, by *spherical* and *cylindrical* wave functions.

The existence and interactions of the particles are in essence, following the DM, a continuous process of wave *exchange* of matter-space-time. The wider (and, hence, truer) notion *exchange* is thus more correct because it reflects behavior of elementary particles in their dynamic equilibrium with the ambient field, at rest and motion, and interactions with other objects (and particles themselves). In other words, the notion *exchange* is more appropriate from the point of view of the physics of the complex behavior of elementary particles viewed as dynamic micro-objects belonging to one of the interrelated levels of the many-level Universe.

Masses of all dynamic formations (micro-particles) in the Universe, according to the DM, have *associated field character* with respect to the deeper level of the field of matter-space- time; therefore, their own (proper, rest) masses do not exist. Associated mass, or briefly the mass of the particle is defined by the formula

$$m = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}, \tag{2.1}$$

where r is the radius of the wave shell;

$$\varepsilon_0 = 1g \cdot cm^{-3}, \tag{2.2}$$

is the *absolute unit density* and ε_r is the *relative density*;

$$k = 2\pi/\lambda = \omega/c, \tag{2.3}$$

is the wave number corresponding to the *fundamental frequencies* ϖ_e of the field of exchange (which are characteristic of the subatomic level of the Universe).

The volumetric rate of mass exchange of the particles with environment called the *exchange charge*, or merely the charge, is defined as

$$\hat{Q} = d\hat{m}/dt = S\hat{\upsilon}\varepsilon, \tag{2.4}$$

where S is the area of a closed surface separating the space of an elementary particles from the surrounding field of matter-space-time, υ is the speed of wave exchange (interaction) at the separating surface. Strictly speaking, the exchange charge is the measure of the rate of exchange of matter-space-time, or briefly the *power of mass exchange.* In this wider sense, the area of exchange S does not necessary concern the closed surface. The symbol " $\hat{}$ " expresses the contradictory (or complex) potential-kinetic character of physical space field [7].

The chargeof exchange $\hat{Q}$ has the active-reactive character because

$$\hat{Q} = Q_a + iQ_r. \tag{2.5}$$

The active component Q_a defines the dispersion during exchange, which in a steady-state process of exchange is compensated by the inflow of motion and matter from deeper levels of space.

The reactive component of charge Q_r, called in contemporary physics the "electric" charge (further for brevity, the charge of exchange Q) is connected with the associated mass m (2.1) by the relation

$$Q = m\omega. \tag{2.6}$$

The *dimensionality* of the exchange charge is $g \cdot s^{-1}$.

Thus, the DM reveals the physical meaning of one of the fundamental notions of physics - the notion of the electric charge. The exchange ("electric") charge is merely the measure of the *rate of exchange* of matter-space-time, or briefly the power of mass exchange; its alternate value changes with the fundamental frequency ω.

The *exchange charge* q is connected with the Coulomb charge q_C, of the dimensionality $g^{\frac{1}{2}} \cdot cm^{\frac{3}{2}} \cdot s^{-1}$ (in the CGSE units), by the formula

$$q = q_c\sqrt{4\pi\varepsilon_0}, \tag{2.7}$$

where $\varepsilon_0 = 1g \cdot cm^{-3}$ is the *absolute unit density.* Hence, the *electron's exchange* (reactive) charge has the value

$$e = e_c\sqrt{4\pi\varepsilon_0} = 1.702691627 \cdot 10^{-9} g \cdot s^{-1}, \tag{2.8}$$

since $\varepsilon_c = 4.803204401 \cdot 10^{-10} CGSE_q$. The absolute value (2.8), the electron's charge, represents an *elementary quantum of the rate of mass exchange.*

The *fundamental frequency* of the wave field of exchange at the *subatomic level* (the frequency of "electrostatic" field) is

$$\omega_e = \frac{e}{m_e} = 1.869162505 \cdot 10^{18} s^{-1}, \tag{2.9}$$

where $m_e = 9.109382531 \cdot 10^{-28} g$ is the electron mass.

The radius of the wave shell of the electron r_e (the electron radius, for brevity), derived from the formula of mass (2.1) under the condition $m = m_e$, $r = r_e$, $k_e = 1/\lambda_e$, $\varepsilon_r = 1$, $c = 2.99792458 \cdot 10^{10}\ cm \cdot s^{-1}$, and

$$\lambda_e = \frac{c}{\omega_e} = 1.603886538 \cdot 10^{-8} cm, \tag{2.10}$$

is

$$r_e = 4.17052597 \cdot 10^{-10} cm. \tag{2.11}$$

In conclusion to this section, we should stress the following important peculiarity of the DM. We regard the physical field-space of the Universe as an infinite series of spaces embedded in each other (recalling a set of nesting dolls, or infinite functional series $(f(x) = \sum_{k=1}^{\infty} u_k(x))$.

This series of spaces expresses the fundamental concept of natural philosophy concerning the infinite divisibility of matter. Every level of space is the basis level for the nearest above-situated level and, simultaneously, it is the level of superstructure for the nearest below-situated level. This means that above-situated field-spaces are formed on the basis of below-lying field-spaces. Accordingly, there is no meaning to the concept of "very last elementary particle" in the common classical sense of this phrase [4], etc.

We will use the above presented fundamental constants (e, ω_e, λ_e, and r_e) for the subsequent derivation of the background spectrum by the chosen here way.

3 A generalized spectral formula for the hydrogen atom

Thus, the hydrogen atom, as a paired wave centrally symmetric proton-electron system, is in a continuous dynamic equilibrium with environment through the wave process of the definite frequency ϖ. The three-dimensional wave equation, for the description of longitudinal oscillations of pulsing spherical wave shell of the proton and the description of transversal cylindrical wave field of the orbiting electron, has the form

$$\Delta \hat{\Psi} - \frac{1}{c} \frac{\partial^2 \hat{\Psi}}{\partial t^2} = 0. \tag{3.1}$$

Spherical and *cylindrical* wave functions satisfying to Equation (3.1) are presented, respectively, as

$$\hat{\Psi} = \hat{R}_1 (kr) \Theta_{l.m}(\theta)\, \hat{\Phi}_m (\varphi)\, \hat{T} (\omega t), \tag{3.2}$$

$$\hat{\Psi}=\hat{R}_m\ (k_r r)\ \hat{Z}\ (k_z z)\ \hat{\Phi}_m\ (\varphi)\ \hat{T}\ (\omega t). \tag{3.3}$$

The longitudinal and transversal components of the spherical-cylindrical field are described over spherical and cylindrical realizations of the wave equation (3.1), which comes in both cases (corresponding to the spatial coordinates r, θ, φ and r, z, φ) to one time equation and three spatial equations.

According to the solutions of (3.1), electron transitions in atoms depend on the structure of their radial shells, i. e., on radial solutions (functions). Radial spherical and cylindrical functions $\hat{R}_l\ (kr)$ and $\hat{R}_m\ (k_r r)$ entred in. (3.2) and (3.3), are uniquely determined by the general structure of the following radial equations:

$$\rho^2 \frac{d^2\ \hat{R}l}{d\rho^2} + 2\rho \frac{d\ \hat{R}l}{d\rho} + (\rho^2 - l(l+1)\ \hat{R}l = 0, \tag{3.4}$$

$$\frac{d^2\ \hat{R}}{d(k_r r)^2} + \frac{1}{k_r r}\frac{d\ \hat{R}}{d(k_r r)} + \left(1 - \frac{m^2}{(k_r r)}\right)\ \hat{R} = 0, \tag{3.5}$$

where $\rho = kr$.

In the *central spherical wave* field of the hydrogen atom, amplitude of radial oscillations of the spherical shell of the proton [4], originated from solutions of (3.4), is

$$A_{shp} = A\ \hat{e}_l\ (kr)/kr, \tag{3.6}$$

where

$$\hat{e}_l\ (kr) = \sqrt{\pi kr/2}(J_{l+\frac{1}{2}}(kr) \pm iY_{l+\frac{1}{2}}(kr)), \tag{3.7}$$

$$k = \omega/c. \tag{3.8}$$

Here $J(kr)$ and $Y(kr)$ are Bessel functions; ω is the oscillation frequency of pulsating spherical shell of the proton equal to the fundamental "carrier" frequency of the subatomic and atomic levels [4, 5]. Zeros and extrema of the Bessel cylindrical functions, $J_{l+\frac{1}{2}}(kr)$ and $N_{l+\frac{1}{2}}(kr)$(or $Y_{l+\frac{1}{2}}(kr)$) are designated, correspondingly, as $J_{(l+\frac{1}{2}),s}, y_{(l+\frac{1}{2}),s}, j'_{(l+\frac{1}{2}),s}$, and $y'_{(l+\frac{1}{2}),s}$. Analogously, zeros and extrema of the Bessel spherical functions are designated as $a_{l,s} = j_{(l+\frac{1}{2}),s}, b_{l,s} = y_{(l+\frac{1}{2}),s}, a'_{l,s}$, and $b'_{l,s}$ [8].

The amplitude energy of the pulsing shell takes the following form

$$E_{shp} = \frac{m_0\omega^2 A^2_{shp}}{2} = \frac{m_0\omega^2}{2}\left(\frac{A}{kr}\right)^2 |\hat{e}_l\ (kr)\ |^2 = \frac{m_0 c^2 A^2}{2r^2}\ |\hat{e}_l\ (kr)\ |^2, \tag{3.9}$$

where m_0 is the proton mass, A is the constant equal to the oscillation amplitude at the sphere of the wave radius ($kr = 1$). Let $kr_0 = z_{l,1}$and $kr_s = z_{l,s}$ where $z_{l,s}$ and $z_{l,l}$ are zeros of Bessel functions $\mathrm{J}_{l+\frac{1}{2}}(kr)$ the following relation between radial shells is valid:

$$r_s = r_0(z_{l,s}/z_{l,l}). \tag{3.10}$$

The subscript l indicates the order of Bessel functions and s, the number of the root. The last defines the number of the radial shell. Zeros of Bessel functions define the radial shells with zero values of radial displacements (oscillations), *i.e.*, the shells of stationary states.

In the *cylindrical wave field*, the energy E_{cyl} as the sum of energies of two mutually-perpendicular potential-kinetic oscillations of the orbiting electron, is equal (in the simplest case) to

$$E_{cyl} = m_e\upsilon^2 = m_e\omega^2 A_{cyl}^2 = m_e\omega^2\left(\frac{a}{\sqrt{kr}}\right)^2 = 2\pi m_e\upsilon A_{cyl}v, \tag{3.11}$$

where m_e is the mass of an electron; r is the radius of its orbit; v is the frequency of its oscillations with the amplitude

$$A_{cyl} = \frac{a}{\sqrt{kr}}; \tag{3.12}$$

and $\upsilon = \omega A_{cyl}$ is the amplitude velocity of the oscillations.

Because $k = \frac{\omega}{c}$,Equation (3.11) reduce to

$$E_{cyl} = hv, \tag{3.13}$$

where $h = \frac{2\pi m_e ca2}{r} = 2\pi m_e\upsilon A_{cyl}$ is an elementary action.

If $kr = \omega r_0/c = \upsilon_0/c$ where υ_0 is the Bohr velocity, then amplitude of oscillations A_{cyl} is equal to the Bohr radius $r_0 : A_{cyl} = \frac{a}{\sqrt{kr}} = r_0$. The constant a, equal to the oscillation amplitude at the Bohr orbit r_0, has thus the value

$$a = \sqrt{hr_0/2\pi m_e c} = 4.52050647 \cdot 10^{-10} cm, \tag{3.14}$$

where $h = 2\pi m_e v_0 r_0 = 6.6260693(11).10^{-27} erg.s$ is the Planck constant.

Since the steady equilibrium exchange (interaction) between spherical and cylindrical fields in the hydrogen atom takes place invariably, the equality

$$E_{cyl} = \Delta E_{sph} \tag{3.15}$$

is always valid. Hence, with allowance for (3.9) and (3.13), we arrive at

$$h\frac{c}{\lambda} = \frac{m_0 c^2 A^2}{2r_0^2}\left(\frac{|\hat{e}_p\,(kr_m)\,|^2\, z_{p,l}^2}{z_{p,m}^2} - \frac{|\hat{e}_p\,(kr_n)\,|^2\, z_{q,l}^2}{z_{q,n}^2}\right) \tag{3.16}$$

Thus, we have arrived at the spectral formula of the hydrogen atom in a general form, wher quantum numbers are roots of Bessel functions. Therefore, we can regard these roots as a mathematical variant of spectral terms.

At $p = q = 0$, zeros of Bessel functions $J_{0+\frac{1}{2}}(z_{0,s})$ are equal to $z_{0,s} = s\pi$ [8] and

$$\mid \hat{e}_0(kr_s) \mid^2 = 1. \tag{3.17}$$

Under this conditional, Eq (3.16) is transformed into an elementary spectral formula for the hydrogen atom:

$$\frac{1}{\lambda} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right), \tag{3.18}$$

where

$$R = m_0 c A^2 / 2hr_0^2 \tag{3.19}$$

is the Rydberg cosntant.

Because $R = R_\infty/(1 + m_e/m_o) = 109677.5833 cm^{-1}$, hence

$$A = r_0\sqrt{2hR/m_0 c} = 9.00935784 \cdot 10^{-13} cm. \tag{3.20}$$

Assuming in the formula (3.6) that kr is equal to the first extremum of the spherical function of the zero order, unequal to zero,

$$kr = \acute{a}_{0,2} = 4.49340946, \tag{3.21}$$

the first maximal amplitude of radial oscillations has the value

$$\langle A_s \rangle = \left(\frac{1}{\sqrt{2}}\right)\frac{A}{kr} = 1.41776041 \cdot 10^{-13} cm. \tag{3.22}$$

The center of masses of the proton, performing such oscillations, forms a *dynamic spherical volume with the radius equal to the amplitude of the oscillations and its volume can be regarded as a nucleus.*

4 The background radiation spectrum of the hydrogen atom

According to the DM, exchange of energy between the proton and the orbiting electron in real conditions occurs, thus, on the background of oscillations of the center of mass of the proton and on the background of exchange with the surrounding field-spaces of a different nature. Hence, the equation of exchange (interaction) should generally be presented as $E_c = \Delta E_s + \delta E$ where δE takes into account various perturbations of the orbital electron motion.

The orbiting electron in hydrogen (both equilibrium and exited states) *constantly* exchanges the energy with the proton at the fundamental frequency inherent in the subatomic level ω_e [5]. This exchange process between the electron and proton has the dynamically equilibrium character and runs on the background of the superimposed oscillatory field. The latter is characterized by a system of radial standing waves, which define "zero level exchange" [6] in a dynamically equilibrium state of the atom.

The frequency spectrum of zero wave perturbation is defined from the equation

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{(n+\delta n)^2}\right), \tag{4.1}$$

where $\delta n = \delta r/r_0$ is the relative measure of background perturbations δr of the orbital radius r_0 (the Bohr radius) at the level of zero exchange.

The δr value consists of two terms:

$$\delta r = \delta r_0 - \frac{r_e}{r_0}\delta r_e. \tag{4.2}$$

The first of them, δr_0, takes into account background perturbations of the orbital motion of an electron regarded as a point-like particle.

According to the DM, an electron, like a proton or any elementary particle, is an expanded (spherical) dynamic formation of a certain radius r_e (2.11), which is approximately in ten times less than the Bohr radius r_0. Oscillations of the center of mass of the electron itself, as a whole, with respect to the center of mass of the hydrogen atom, reduce the effective value of δr_0. The second term in (4.2) $(r_e/r_0)\delta r_e$ with the minus sign takes into account this circumstance.

In the spherical wave field of the hydrogen atom, both quantities, δr_0 and δr_e are determined, as follows from (3.6), by roots of Bessel functions and depend on the value of the constant A. The term δr_0 has the form

$$\delta r_0 = \frac{Ae_p(z_{p,s})}{z_{p,s}} = \frac{A}{z_{p,s}}\sqrt{\frac{\pi z_{p,s}}{2}\left(J_p^2(z_{p,s}) + Y_p^2(z_{p,s})\right)}, \tag{4.3}$$

where the constant A is defined by (3.20). The term δr_e has the analogous form

$$\delta r_e = \frac{A_e e_m(z_{m,n})}{z_{m,n}} = \frac{A_e}{z_{p,s}}\sqrt{\frac{\pi z_{m,n}}{2}\left(J_m^2(z_{m,n}) + Y_m^2(z_{m,n})\right)}, \tag{4.4}$$

where the constant A_e differs from A (3.20) because it is defined as

$$A_e = r_e\sqrt{\frac{2Rh_e}{m_0 c}}. \tag{4.5}$$

In this formula, r_e is the theoretical radius of the wave shell of the electron (the electron radius for brevity) (2.11) determined in the DM from the formula of mass of elementary particles (2.1).

The quantity h_e entered in (4.5),

$$h_e = 2\pi m_e v_0 r_e = 5.222105849 \cdot 10^{-28} erg \cdot s, \tag{4.6}$$

is the orbital action of the electron (analogous to the Planck constant h) caused by its proper rotation around own center of mass with the speed v_0. The rotation is realized during the electron orbiting around the proton with the same (Bohr) speed

$$v_0 = 2.187691263 \cdot 10^8 cm \cdot s^{-1}. \tag{4.7}$$

Substutingall quantities in (4.5), we obtain

$$A_e = 1.993326236 \cdot 10^{-14} cm. \tag{4.8}$$

The final condition concerns the choice of the numerical factor β_n multiplied by $(r_e/r_o)\delta r_e$ in the case of the roots $z_{p,s} = j'_{p,s}$. The matter is that roots $y_{p,s}$ represent equilibrium kinetic radial shells, whereas $j'_{p,s}$ represent extrema of potential shells [9] exhibited under the excitation of the hydrogen atom (note that $j'_{0,2} = j_{1,1}, j'_{0,3} = j_{1,2}$, ...,where $j_{p,s}$ are zeros of potential shells). Hence, for the exited atom, the value δr will be slightly differing from the equilibrium value defined by (4.2).

We take into account the above circumstance, varying insignificantly the smallest (second) term in (4.2) by the empirical numerical factor β_n, so that the equality (4.2) takes the form:

$$\delta r = \delta r_o - \beta_n \frac{r_e}{r_0} \delta r_e. \tag{4.9}$$

Thus, we have arrived at the following resulting formula for δn:

$$\delta n = \frac{\delta r}{r_0} = \sqrt{\frac{2Rh}{m_0 c}} \cdot \frac{e_p(z_{p,s})}{Z_{p,s}} - \beta_n \frac{r_e^2}{r_0^2} \sqrt{\frac{2Rh_e}{m_0 c}} \cdot \frac{e_m(z_{m,n})}{Z_{m,n}}. \tag{4.10}$$

The roots of Bessel functions and empirical values of β_n, taken for calculations by (4.10), are presented in Table I for the first two quantum numbers, $n = 1$ and $n = 2$.

s	$Z_{p,s}$[8]	$Z_{m,n}$[8]	$\beta_1(n=1)$; $\beta_2(n=2)$
1	$y_{0,1} = 0.89357697$	$y'_{0,1} = 2.19714133$	
2	$y_{0,2} = 3.95767842$	$y'_{0,1} = 2.19714133$	
	$j'_{0,2} = 3.83170597$	$j'_{\frac{1}{2},1} = 1.16556119$	$\beta_1 = 1.203068949$
			$\beta_2 = 1.018671584$
3	$y_{0,3} = 7.08605106$	$y'_{0,1} = 2.19714133$	
	$j'_{0,3} = 7.01558667$	$j'_{\frac{1}{2},1} = 1.16556119$	$\beta_1 = 1.203068949$
			$\beta_2 = 1.018671584$

Table I. Roots of Bessel functions and β_n used for calculations by (4.1), $n = 1, 2$

On the basis of the formula (4.1), with allowance for (4.10) and the data of Table I, we estimate a few most probable perturbations of the stationary ($n = 1$) and exited ($n = 2$) states in the hydrogen atom for the case with $p = m = 0$ and $s = 1, 2$, and 3.

The results of calculations by the formula (4.1) under the above conditions are presented in Tables II - IV.

s	$Z_{p,s}$	$Z_{m,n}$	β_n	$1/\lambda, cm^{-1}(4.1)$	λ, cm	T, K	$T_{exp,}, K$[10]
1	$y_{0,1}$	y'$_{0,1}$		41.751724	0.023951	12.10805	
2	$y_{0,2}$	y'$_{0,1}$		9.40602023	0.106315	2.72774	2.728 ± 0.002
	j'$_{0,2}$	j'$_{\frac{1}{2},1}$	β_1	9.647863723	0.103320	2.80680	
3	$y_{0,3}$	y'$_{0,1}$		5.240486	0.190822	1.51974	
	j'$_{0,3}$	j'$_{\frac{1}{2},1}$	β_1	5.255841	0.190265	1.52419	

Table II. Spectral terms of background radiation of the hydrogen atom, for $n = 1$

s	$Z_{p,s}$	$Z_{m,n}$	β_n	$1/\lambda, cm^{-1}(4.1)$	λ, cm	T, K
1	$y_{0,1}$	y'$_{0,1}$		5.219748	0.191580	1.5137
2	$y_{0,2}$	y'$_{0,1}$		1.1758681	0.850436	0.3410
	j'$_{0,2}$	j'$_{\frac{1}{2},1}$	β_2	1.211154	0.825659	0.3512
3	$y_{0,3}$	y'$_{0,1}$		0.6550701	1.526554	0.18997
	j'$_{0,3}$	j'$_{\frac{1}{2},1}$	β_2	0.6582849	1.519099	0.1909

Table III. Spectral terms of background radiation of the hydrogen atom, for $n = 2$

n	s	Terms differences	$\Delta(1/\lambda), cm^{-1}$	$\Delta v, MHz$	$\Delta v_{\exp}, MHz$ [11]
1	2	$(\text{j'}_{0,2} - y_{0,2})_{n=1}$	0.272617	8172.852	8172.837(22)
	3	$(\text{j'}_{0,3} - y_{0,3})_{n=1}$	0.015355	460.3313	
2	2	$(\text{j'}_{0,2} - y_{0,2})_{n=2}$	0.0352859	1057.84466	1057.8446(29)
	3	$(\text{j'}_{0,3} - y_{0,3})_{n=2}$	0.0032148	96.37727	

Table IV. Frequency gaps between the nearest background terms in the hydrogen atom

We see that at $p = 0$, the zero of the second knitec shell [6] is $z_{0,2} = y_{0,2} = 3.95767842$; hence, from (4.1) it follows that:

$$\lambda = 0.106315 \ \ cm. \tag{4.11}$$

The zero level of wave exchange (interaction with environment) is not perceived visually and integrally characterized by the absolute temperature of zero exchange. It exists as a standard energetic medium in the Universe. Actually, the wave (4.11) is within an extremum of the spectral density of equilibrium cosmic background.

The absolute temperature of zero level radiation with this wavelength is

$$T = 0.290(cm \cdot K)/\lambda = 2.72774 \ \ K. \tag{4.12}$$

The temperature obtained is close to the temperature of "relict" background measured by NASA's Cosmic Background Explorer (COBE) satellite to four significant digits ($2.728 \pm 0.002K$)[10].

The theoretical values obtained for the $(\mathrm{j'}_{0,2} - y_{0,2})_{n=1}$ and $(\mathrm{j'}_{0,2} - y_{0,2})_{n=2}$ terms differences (Table IV) almost coincide with the experimental values for the $1S$ and $2S$ Lamb shifts $L_{1,s} = 8172.837(22)$ MHz and $L_{2s-2p} = 1057.8446(29)$ MHz [11].

Accuracy of the first elementary calculations, presented in Tables, performed on the basis of (4.1), can be easily improved owing to the relative clarity with the factors which can be exposed to the possible corrections. Actually, only the constant A or A_e, defining the oscillation amplitude at the sphere of the wave radius ($kr = 1$), can be changed in (4.3) or (4.4).

5 Conclusion

In view of the data obtained, the observation of the cosmic microwave background and the Lamb shifts provide strong evidence for the existence of zero level radiation of hydrogen (and, apparently, any) atoms in the Universe. They justify in favor of the validity of the background spectrum expressed by the formula (4.1) (with allowance for (4.10)) and of the Dynamic Model of Elementary Particles [5], which is the basis model for the derivation of the spectrum.

Owing to the DM, which led to the formula of the background spectrum of the hydrogen atom, the common nature of two phenomena found in the 20^{th} century - the Lamb shift and "relict" background radiation (cosmic microwave background, CMB) - was revealed.

A discovery of such a fundamental regularity in Nature is a logical result of an advantage of the new theoretical basis used here. As was mentioned in Sect. 2, the DM revealed the nature of mass, the nature and true dimensionality $g \cdot s^{-1}$, of the electric charge. The latter is defined in the DM as the *rate of mass exchange*. With this, the unknown earlier fundamental constant, namely the fundamental frequency of exchange (interaction) at the atomic and subatomic levels ω_e, was found, *etc.* Without aforementioned (and others not mentioned here) revelations, which show an advantage of the DM as against the Standard Model of Elementary Particles, the results presented could not be appeared.

The background spectrum obtained contains the line of the wavelength $\lambda = 0.106315$ *cm* corresponding to the 2.728 K temperature. The radiation of such a temperature exists in cosmic space just because of immense abundance of hydrogen there that was measured by research satellites [10]. The hydrogen hypothesis of the origin of the background temperature is confirmed by the energetic structure of the background spectrum of the hydrogen atom. Actually, the frequency gaps 8172.852 MHz and 1057.8447 MHz between the nearest background terms (see Table IV) coincide with high precision with the most accurate experimental values [11] obtained for the 1S and 2S Lamb shifts of the hydrogen atom.

The results presented call in questions some accepted hypotheses, concepts, and theories. First, they touch a hypothesis of origin of the CMB 2.7 K temperature regarded by the majority as a "relict" background radiation left after the Big Bang. A historical and critical analysis of theories explaining the origin of the 2.7 K background temperature can be found in [12]. Second, they nonplus the QED concept of "virtual" particles introduced initially just for explanation of the Lamb shifts and "anomalous" magnetic moment of an electron [13]. Third, these results question the quantum mechanical *probabilistic* atomic model in which the notion of *trajectory* of motion (along which an electron orbits around a proton) is excluded of principle [9].

In addition, the words "splitting" or (Lamb) "shift" are not correct names for the observed phenomenon. All background terms described by the resultant formula (4.1) (contained the roots of Bessel functions) are primordially inherent features of the hydrogen atom; so that they neither "split" nor "shift". Accordingly, we should speak only about the energetic differences (or frequency gaps) between the existed background terms.

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