Microwave background radiation of hydrogen atoms

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Abstract: *We show that the microwave background radiation, observed in Cosmos, apparently, is the zero-level (background) radiation of all atoms in the Universe. This radiation naturally originates from the dynamic model of microparticles, where the hydrogen atom is regarded as a paired proton-electron system with the binary wave spherical-cylindrical field. Optical spectrum of the exited H-atom and background radiation-absorption spectrum of the H-atom, being in equilibrium with the wave field-space of the Universe, are derived here on the basis of such a model.*

Key words: *background radiation, atomic spectra, hydrogen atom, cosmology*

1 Introduction

The background radiation of *H*-atoms was not considered before [1, 2]. This omission happened because of the domination of quantum mechanical concepts on the structure of atoms, fully formed among scientists and unquestioned hitherto. These concepts originate from the Bohr Theory and kept its essential features. In accord to one of them, *an atom does not emit energy being in equilibrium.* But we have reasons to doubt whether this is true.

According to the *dynamic model* of microobjects of atomic and subatomic levels [3-5, 6], the hydrogen atom, as a paired proton-electron system, represents by itself the stable wave system of the longitudinal-transversal structure. The wave *exchange* (interaction) takes place continuously between the *longitudinal* (*spherical*) wave field of the proton and *transversal* (*cylindrical*) wave field of the orbiting electron. The notion *exchange* instead of *interaction* reflects wave behavior of "elementary" particles in their dynamic equilibrium with the ambient field, *at rest and motion*, and interactions with other objects. The wave exchange occurs at the fundamental frequency of the atomic and subatomic levels, lying within the exafrequency band: $\omega_e = e/m_e = 1.869161986 \times 10^{18}\, s^{-1}$ [6].

Thus, following the dynamic model, the *H*-atom is a paired dynamic system with the central spherical microobject of a complicated structure (proton) and the *orbiting* electron. Both proton and electron are in a dynamic equilibrium between themselves and environment through the wave process of the frequency ω_e. The *spherical wave field of the proton* is closed on to the *cylindrical wave field of the orbiting electron* and partly on to the ambient field-space. In other words, *longitudinal oscillations* of the proton's wave shell in the radial direction provide its interaction with the electron and environment. The detail description of the dynamic model of "elementary" particles is in the work [6].

As long as the dynamic equilibrium exchange exists, inside the *H*-atom (proton-electron system) and between the *H*-atom as a whole and the ambient field of matter-space-time, the system is stable and neutral. Under ionization, the dynamic equilibrium inside and between the *H*-atom and the ambient field-space is broken. In this case, *H*-atom, as H^+-ion (proton), is regarded as a charged particle with the charge equal, in value, to the electron charge, but with the opposite sign. Thus, the value of the charge gives the correct amplitude measure of violation of dynamic equilibrium. The uncompensated exchange of the field of proton with electron, at the fundamental frequency ω_e, exhibits itself in ionized *H*-atom (H^+-ion) as exafrequency exchange of the proton directly with the ambient field-space. That allows ascribing the positive charge to the H^+-ion, equal in value to the electron charge.

The stable states of the *H*-atom form, in the exafrequency wave field, the *spectrum of dynamically stationary states* (defined by characteristic values of arguments of Bessel functions [7]) and generate the *background spectrum of zero level radiation* responding, as it turned out, to the black-body radiation of approximately 2.73 K temperature.

It is no wonder that the *H*-atom has background radiation. Similarly as any electron system at the macrolevel, the *H*-atom (and, hence, any atom), as an elementary electron system at its (micro-) level, must be characterized by background radiative noise caused by orbital current noise of orbiting electrons. The *H*-atom background had to have extremely small intensity and its observation can be possible and effective only on the immense scale of *H*-atoms abundance, i.e., in Cosmos. Fortunately, the current research of microwave background, carrying out intensively in Cosmos [1], can verify the validity of the dynamic model proposed and, in this connection, once more the Big Bang hypothesis of the origin of the Universe − the urgent point of natural science.

We will show below, as simple and clear as possible, the derivation of the both aforementioned spectra. For this aim, we will lay stress mainly on the wave motion of the electron along the orbit taking into account that one half-wave of the fundamental tone of the electron is placed on the Bohr first orbit (it follows from the strict solution of the wave equation, which is described by the Bessel wave function of the order 1/2 [5]). But at first let us present essential energy relations originated from the dynamical model of the *H*-atom, which are necessary for further consideration.

2 Energy relations

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

$$v = \frac{v_s}{kr} \tag{2.1}$$

where v_s is the amplitude of velocity of the spherical field, corresponding to the condition $kr = 1$; $k = 2\pi/\lambda$ is the wave number corresponding to the fundamental frequency ω_e of the field of exchange, the *constant* quantity [6]. The expression (2.1) is the effect of constancy of the energy flow in the elementary spherical field, which is described by the cylindrical functions of the order 1/2. However, it is approximately valid also for spherical fields, which are described by the spherical functions of higher orders, under the condition $kr \gg 1$.

If r_0 is the radius of the first stationary shell and v_0 is the velocity on it, then, at the constant k, we have the following relations for the radii and velocities of stationary shells

$$r = r_0 n, \qquad v = v_0/n \tag{2.2}$$

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

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

$$v = v_c/\sqrt{kr} \tag{2.3}$$

where v_c is the amplitude of velocity of the cylindrical field. Because k is the constant, we obtain the following relations for the stationary shells

$$r = r_0 n, \qquad v = v_0/\sqrt{n} \tag{2.4}$$

The formulae (2.3) and (2.4) are approximately valid for the heterogeneous cylindrical fields under the condition $kr \gg 1$.

According to the theory of *circular* motion [5], the energetic measures of rest and motion are represented by the opposite, in sign, kinetic and potential energies equal in value. Because any insignificant part of an arbitrary trajectory is equivalent to a small part of a circumference, any wave motion of an arbitrary microparticle (and, in an equal degree, a macro and megaobject) is characterized by the kinetic and potential energies also equal in value and opposite in sign

$$E_k = mv_k^2/2, \qquad E_p = m(iv)_p^2/2 = -mv_p^2/2 \tag{2.5}$$

Hence, the total potential-kinetic energy of any object in the Universe is equal to zero

$$E = E_k + E_p = 0$$

and its amplitude is equal to the difference of kinetic and potential energies

$$E_m = E_k - E_p = mv^2 \tag{2.6}$$

Thus, because the circular motion is the sum of two mutually perpendicular potential-kinetic waves, the amplitude energy of an orbiting electron is

$$E = mv_m^2 = m\omega^2 A_m^2 = \frac{m\omega^2 A^2}{kr} = \frac{m\omega^2 A^2}{\frac{\omega}{v} r} = \frac{mA^2 v}{r}\omega = \hbar_e \omega \tag{2.7}$$

where A is the amplitude of the *traveling* wave. Let us rewrite (2.7) as

$$E = \hbar_e \omega = h_e \nu = h_e \frac{v}{\lambda_e} \tag{2.8}$$

where λ_e is the electron wave of H-atom space

$$\hbar_e = \frac{mA^2 v}{r} \qquad \text{and} \qquad h_e = \frac{2\pi m A^2 v}{r} \tag{2.9}$$

are the *radial* and *azimuth electron actions*, respectively.

In the space of the stationary field of *standing waves*, we have the similar relations

$$\hbar_e = \frac{ma^2 v}{r} \qquad \text{and} \qquad h_e = \frac{2\pi m a^2 v}{r} \tag{2.10}$$

where $a = 2A$ is the amplitude of the standing wave.

On the other hand, the electron is in the *spherical field* of H-atom, where its action $mvr = \hbar$ is the *constant* value. Hence, at $r = r_0$, we have $a = r_0$, $v = v_0$ and

$$\hbar_e = mv_0 r_0 \tag{2.11}$$

Under the perturbations, the wave atomic space of the wave frequency $\omega = 2\pi v_0/\lambda_e$, induces outside the atomic space the external waves of the same frequency, but with the speed c and wavelength λ, so that

$$\omega = \frac{2\pi v_0}{\lambda_e} = \frac{2\pi c}{\lambda} \tag{2.12}$$

Therefore, the electron energy can be presented also as

$$E = \hbar_e \omega = h_e \nu = h_e \frac{c}{\lambda} = \frac{1}{2} h_\lambda \frac{c}{\lambda} \tag{2.13}$$

where $h_e = 2\pi m v_0 r_0$ is the action of the electron (an *elementary wave action*), $h_\lambda = 4\pi m v_0 r_0$ is *the wave action of the wave of the fundamental tone.* With that, the electron's wave energy is equal its kinetic energy on the orbit

$$E = \hbar_e \omega = m v_0 r_0 \omega = m v r \omega = \frac{1}{2} m v r \omega_{\rm orb} = \frac{1}{2} m v^2 \tag{2.13a}$$

where $\omega = \omega_{\rm orb}/2$ is the circular wave frequency of the fundamental tone and $\omega_{\rm orb}$ is the circular frequency of electron's revolution along the orbit, for which $v = r\omega_{\rm orb}$; the relation $v_0 r_0 = vr$ is the effect of the constancy of the energy flow in the elementary spherical field or the constancy of the elementary wave action $mvr = \hbar$.

Thus, the energy of the overtones (see (2.3) and (2.7)) is

$$\varepsilon = mv^2 = m v_0 \omega a_0 n = \hbar \omega n = h\nu n \tag{2.14}$$

In such a case, for the Bohr orbit, the following ratio (for the total energy) is valid

$$\frac{v^2}{v_\sigma^2} = \frac{h\nu n}{\varepsilon_\sigma} = \frac{h\nu n}{kT} \tag{2.15}$$

where v_σ is the most probable speed, ε_σ is the most probable quantum of energy, $h = 2\pi m v_0 r_0$ is the Planck azimuth wave action, and $T = \varepsilon_\sigma/k$ is the most probable relative energy (the "absolute" temperature). Probabilities of energy states w are described by the approximate Gauss' formula

$$w = C\exp(-v^2/v_\sigma^2) = C\exp(-h\nu n/\varepsilon_\sigma) = C\exp(-h\nu n/kT) \tag{2.16}$$

Hence, according to the equation (2.15), the mean value of energy of excitation (of a shell of H-atom) is

$$\langle \varepsilon_\nu \rangle = \frac{\sum h\nu n \Delta w_n}{\sum \Delta w_n} = h\nu \frac{\sum\limits_{n=0}^{\infty} n\exp(-nh\nu/kT)}{\sum\limits_{n=0}^{\infty} \exp(-nh\nu/kT)} = \frac{h\nu}{\exp(h\nu/kT) - 1} \tag{2.17}$$

3 H-atom optical spectrum; Rydberg constant

Let us assume that the electron orbit is in the plane $z = 0$. Because *the electron is the node of the wave orbit*, hence, the boundary orbital conditions at the instant $t = 0$ must express the equality to zero of potential azimuth displacements in the node during one revolution [5]

$$\mathrm{Re}\exp\left(-i(\varphi/2 + \varphi_0)\right)|_{\varphi=0} = \mathrm{Re}\exp\left(-i(\varphi/2 + \varphi_0)\right)|_{\varphi=2\pi} = 0 \tag{3.1}$$

These conditions are realized for the traveling electron wave in the positive direction if, e.g., $\varphi_0 = \pi/2$. In such a case, Ψ-function of the electron takes the form

$$\Psi^+_{1/2} = iA\frac{e^{i(\omega t - kr)}}{\sqrt{kr}} e^{-i(\varphi/2 + \pi/2)} e^{-ik_z z} \tag{3.2}$$

The function (3.2) describes the *wave of the fundamental tone of the electron* λ_e. Its length is equal to the doubled length of the electron orbit of the Bohr radius r_0 [5]

$$\lambda_e = 4\pi r_0 \tag{3.3}$$

The wave motion of the fundamental tone occurs *in the nearest layers of the wave atmosphere* of the H-atom, almost at its surface. The *equilibrium wave interchange of energy* takes place between the H-atom and the surrounding field of matter-space-time [6]. However, under the perturbations, the electron wave (3.3) *can reiterate itself in the cosmic wave* of the same frequency (see (2.12))

$$\lambda = \frac{4\pi r_0}{v_0} c \tag{3.4}$$

The inverse quantity of this wave is the Rydberg constant

$$R = \frac{1}{\lambda} = \frac{v_0}{4\pi r_0 c} = \frac{1}{T_0 c} \tag{3.5}$$

The electron realizes the transitions of the H-atom from the n-th into m-th energetic state; it is the wave motion with the energy of transition (2.13). The law of conservation of energy, at such an extremely fast "quantum" transition, can be presented by the equality

$$E_m + h\frac{c}{\lambda} = E_n \tag{3.6}$$

Taking into account the equations (2.4), and (2.5), the potential energy of the electron in the spherical field of the H-atom is $E = -\frac{mv_o^2}{2n^2}$. As a result, we arrive at the following equation of the energetic balance

$$h\frac{c}{\lambda} = E_n - E_m = \frac{mv_0^2}{2}\left(\frac{1}{m^2} - \frac{1}{n^2}\right) \tag{3.7}$$

Hence, we obtain

$$\frac{1}{\lambda} = \frac{mv_0^2}{2hc}\left(\frac{1}{m^2} - \frac{1}{n^2}\right) \tag{3.8}$$

Thus, in the strict correspondence with the wave theory, we arrive at the spectral formula of H-atom (see also [8]) and the Rydberg constant

$$R = \frac{mv_0^2}{2hc} = \frac{v_0}{4\pi r_0 c} \tag{3.9}$$

Note finally that in accordance with the strict solutions in the framework of the approach developed elementary optical classes of spectra in a general case are defined by the following formula of energetic transitions [5]

$$\frac{1}{\lambda} = R\left(\frac{e_p^2(z_{p,m}) z_{p,1}^2}{z_{p,m}^2} - \frac{e_q^2(z_{q,n}) z_{q,1}^2}{z_{q,n}^2}\right) \tag{3.10}$$

where

$$e_p(z_{r,s}) = \sqrt{\frac{\pi z_{r,s}}{2}\left(J_r^2(z_{r,s}) + Y_r^2(z_{r,s})\right)} \tag{3.11}$$

$J_r(z_{r,s})$ and $Y_r(z_{r,s})$ are Bessel functions; $z_{r,s}$, $z_{p,m}$, $z_{q,n}$ are zeros of Bessel functions; the subscripts p, q, r indicate the order of Bessel functions and m, n, 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., shells of stationary states.

4 Background radiation spectrum

The electron in *H*-atom under the wave motion exchanges the energy with the proton constantly at the fundamental frequency ω_e. This exchange process between the electron and proton has the dynamically equilibrium character. It is represented by a system of radial standing waves, which define "zero level exchange" [5] in a dynamically stable state of the atom. The frequency of zero wave perturbation is

$$\nu_0 = R\left(\frac{1}{n^2} - \frac{1}{(n+\delta n)^2}\right) \tag{4.1}$$

where $\delta n = \delta r_n / r_1$ is the relative measure of casual perturbations δr_n of the orbital radius r_1 at the level of zero exchange, R is the Rydberg constant. In the spherical wave field of the *H*-atom, we have

$$\delta r_n = \frac{A e_p(z_{p,s})}{z_{p,s}} = \frac{A}{z_{p,s}}\sqrt{\frac{\pi z_{p,s}}{2}\left(J_p^2(z_{p,s}) + Y_p^2(z_{p,s})\right)} \tag{4.2}$$

where $A = r_0\sqrt{2hR/m_p c}$ is the constant equal to the oscillation amplitude at the sphere of the wave radius $r = 1/k = \lambda/2\pi$; $z_{p,s}$ are roots of Bessel functions J_p and Y_p; m_p is the proton mass; r_0 is the Bohr radius; h is the Planck constant. Thus, we obtain the following spectrum of waves, generated by the perturbations of stationary states of the *H*-atom

$$\frac{1}{\lambda} = \frac{R}{n^2} - \frac{R}{\left(n + \frac{A}{r_1 z_{p,s}}\sqrt{\frac{\pi z_{p,s}}{2}\left(J_p^2(z_{p,s}) + Y_p^2(z_{p,s})\right)}\right)^2} \tag{4.3}$$

Let us estimate one of the most probable perturbations of the stationary state ($n = 1$), assuming that $R = \dfrac{R_\infty}{1 + m_e/m_p} = 109677.5831\,cm^{-1}$ and $A = r_0\sqrt{2hR_\infty/m_p c} = 9.01812058 \times 10^{-13}\,cm$.

At $p = 0$, the zero of the second *kinetic shell* [5] is $z_{0,2} = y_{0,2} = 3.95767842$ [9], hence

$$\lambda = 0.106267\ cm \tag{4.4}$$

This wave must be within an extremum of the spectral density of equilibrium radiation. This allows estimating the absolute temperature of zero level of radiation

$$T = \frac{0.290\, cm \cdot K}{\lambda} = 2.7289\, K \approx \Delta K \tag{4.5}$$

where $\Delta = 2\pi \lg e = 2.7288$ is the measure of the *fundamental period* (*fundamental quantum of measures*) [3, 10, 11]. The temperature obtained coincides with the temperature of "relict" background measured by NASA's Cosmic Background Explorer (COBE) satellite to four significant digits ($2.725 \pm 0.002\, K$).

Thus, the formula (4.1) defines the waves of radiation-absorption of extremely small intensity and relatively large length, which are characteristic for components of waves of zero exchange. The zero level of exchange is not perceived visually and integrally characterized by the absolute temperature of zero exchange. It is perceived only as a standard energetic medium. Its spectrum is well characterized by a black-body (Planckian) spectrum [1]. We will show it now.

5 The Planckian character of background radiation

Let us consider the balance radiation in a volume of an arbitrary cavity, which serves as a model of a "black body". We will do it also from the unknown earlier point of view. In this case, to compute the number of standing waves in the cavity, it is quite sufficient to compute a number of fundamental oscillations, taking into account that one *H*-emitter corresponds to every elementary standing wave. It is the extremely simplest way of the Planck's law derivation.

During the one wave period of the fundamental tone, the electron on the Bohr orbit twice runs the azimuth orbit (see (3.3)), hence, the *linear density of elementary half-waves* n_{lin}, placed on Bohr orbits is

$$n_{lin} = \frac{2}{\lambda} \tag{5.1}$$

The *volumetric density* can be determined from the equality

$$n_{vol} = n_x n_y n_z = n_{lin}^3 = \frac{8}{\lambda^3} = \frac{8\nu^3}{c^3} \tag{5.2}$$

and the *spectral density* by the ratio

$$n_\nu = \frac{dn_{vol}}{d\nu} = \frac{24\nu^2}{c^3} \tag{5.3}$$

Because every standing wave is related to one *H*-emitter of the mean energy $\langle \varepsilon_\nu \rangle$ (2.17), the spectral density of radiation will be equal to

$$u_\nu = n_\nu \langle \varepsilon_\nu \rangle = \frac{3}{\pi} \frac{8\pi\nu^2}{c^3} \frac{h\nu}{e^{h\nu/kT} - 1} \tag{5.4}$$

A part of the density of spectral flux of energy, $u_\nu c$, through an elementary area of $\Delta S = \pi r^2$, along all directions, defines the *energetic spectral luminosity* of atomic space

$$r_\nu = u_\nu c \frac{\Delta S}{4\pi r^2} = \frac{1}{4} u_\nu c \tag{5.5}$$

Hence, we arrive at

$$r_\nu = \frac{3}{\pi} \frac{2\pi\nu^2}{c^2} \frac{h\nu}{e^{h\nu/kT} - 1} \tag{5.6}$$

and the integral luminosity (the Stefan-Boltzmann law) takes the following form

$$R_e = \sigma_e T^4, \qquad \text{where} \qquad \sigma_e = \frac{3}{\pi}\sigma = \frac{2\pi^4 k^4}{5c^2 h^3} \tag{5.7}$$

If we introduce the mean spectral-temperature coefficient of radiation ζ (in the capacity of qualitatively similar states of atoms) and the multiplier

$$\varepsilon_\zeta = (3/\pi)\zeta \tag{5.8}$$

then

$$R_e = \varepsilon_\zeta \sigma T^4 \tag{5.9}$$

Planck's law is an approximate guideline; therefore, the factor $3/\pi$ in the formula (5.7) has no principal meaning. In practice, the deviation from Planck's law is connected with the empirical spectral and integral coefficients of radiation. Accordingly, an application of the law to real systems, for example the stars, is possible only with essential assumptions.

6 Conclusion

1. For the first time the *spectrum of microwave background radiation of hydrogen atoms* (4.3) *was derived theoretically.* The background radiation is exactly that of a "black body" with approximately 2.73 K temperature. The aforementioned spectrum, as well as the optical spectrum of *H*-atom, was obtained taking into account the *orbital* (circular) motion of the *electron-wave*, where the *electron-particle* is regarded as the *node of the wave orbit.*

2. We believe that together with the observed data on the cosmic microwave background [1], the data obtained *provide strong evidence for the existence of zero level radiation of hydrogen* (and, hence, any) atoms in the Universe.

3. The results presented, along with other data of the authors obtained in the framework of new approach [3-5], once more *confirm the validity of the dynamic model of microobjects of atomic and subatomic levels* [6, 12], where the *H*-atom represents by itself a paired dynamic system of quasispherical structure with the orbiting electron-satellite. The spherical component (ionized *H*-atom, proton) relates to the spherical wave field of exchange (interaction). The electron-satellite (its motion) relates to the cylindrical wave field of exchange. The spherical field is a

field of contents (the basis of H-atom) and the cylindrical field is a field of the form (the superstructure of H-atom).

4. The concept on the zero level radiation of H-atoms *questions the Big Bang hypothesis* of the origin of the Universe and quantum mechanical *probabilistic model*, which excludes an electron's orbital motion *along a trajectory* as a matter of principle. Therefore, it must attract a special attention of physicists and should be affected to the detail analysis.

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