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Electromagnetic Oscillator Action as an Introduction to Discrete Physics

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Abstract

The aim of this study is to define both the structural constant of all atoms s_0 and the action of *LC* oscillator *A*, as a new concept. The methods of theoretical research are used, and its checking is based on previously measured data. Electromagnetic radiation, which we observe in an area outside of the atom, has its source in the atom. As a model of this source an *LC* oscillator was investigated within the atom. It is determined that the energy of that *LC* oscillator is proportional to its natural frequency. However, the proportionality factor *A*, which is analogous to Planck's *h*, is not constant, but decreases with the increase in this frequency. Periodic coincidence of two independent phenomena within an atom is condition of the stability of an atom. These two phenomena are, first, circulating the electron around the nucleus, and second, oscillating the electromagnetic energy in the atom. At the integer frequency ratio of these two phenomena, discretization of the atoms state occurs. The structural constant and its unified value is defined; s_0=8.278691910. All NIST Data, from Hydrogen, $_1$H, to Darmstadtium, $_{110}$Ds, 110 metrics, confirmed this value. This approach, besides the atomic shell, includes its nucleus. It is shown that with help of structural constant s_0, as well with help of the other five known constants (c, μ_0, e, m, m_p), nine existing constants become redundant; *i.e.*, fine structure constant α, von Klitzing constant R_K, Planck's *h*, ratio *e*/*h*, Josephson constant K_J, Rydberg constant R_∞, Bohr radius a_0, Bohr magneton μ_B, and nuclear magneton μ_N. All relevant physical quantities are also given in a form suitable for use in Discrete Physics. All relations in Discrete Physics are as clear as in Classical Physics.

Keywords

Discrete Physics, Discrete States of Atoms, Lecher Line, Maxwell's Equations, Structural Constant, Unit for Type of Substance

1. Introduction

At the very beginning, it should be noted that the theory presented here is based on Maxwell's electromagnetism and on relativity theory. Emission of radiation during acceleration, known as radiation reaction [1], or radiation caused by the mechanical oscillation of charge [2, 3], are much less in relation to the radiation resulting from the assumed *LC* oscillator in the atom. This *LC* oscillator I use after I read Planck's review on the Bohr model of the atom [4]. Complaints about the collapse of atoms in such theories are eliminated through full access to the atom which includes emission and absorption of the radiation [5, 6], where it is possible to absorb and its own radiation emission. Electromagnetic radiation, which we observe in an area outside of the atom, has its source in the atom. As a model of this source an *LC* oscillator was investigated within the atom.

2. The Atom as an *LC* Oscillator

The *LC* oscillator is most commonly used to generate electromagnetic waves for practical use, for example radio, television or communication signals. However, it is theoretically possible to obtain any electromagnetic wave of resonant frequency $\omega = 2\pi f = 1/\sqrt{LC}$ using the *LC* oscillator. Emitted electromagnetic energy E_{em} of such oscillator can be calculated in several ways. One way is to integrate the entire energy of the emitted electromagnetic fields [7],

$$E_{em} = \tfrac{1}{2}\iiint \left(\boldsymbol{E}\cdot\boldsymbol{D} + \boldsymbol{H}\cdot\boldsymbol{B}\right) dx\, dy\, dz \,, \tag{1}$$

where $\boldsymbol{E}$ and $\boldsymbol{H}$ are electric and magnetic field respectively, $\boldsymbol{D}$ is electric displacement and $\boldsymbol{B}$ is magnetic induction.

Another way is to calculate the loss of energy of the *LC* oscillator as a source of electromagnetic energy, with use the law of conservation of energy; this means that the energy emitted by *LC* oscillator becomes the energy of the electromagnetic wave. We will consider the situation that the source of the electromagnetic wave is a structure of the substance that it consists of a central body with a charge *Q*, while around this body at a distance *r* (orbit radius), with uniform speed *v* in circular motion revolving the body with mass *m* and with the charge *q*. Then it is $v/c = \beta$, and *c* is the speed of light in vacuum. This moving body has an acceleration directed radially toward the center the circle, *i.e*., at right angel to the vector of velocity **v** of magnitude [8] v^2/r . Relativistic moment $\boldsymbol{p}$ of moving body, [8], is

$$\boldsymbol{p} = \frac{m\,\mathbf{v}}{\sqrt{1-\beta^2}} \,. \tag{2}$$

In the stationary state, when the variables are at their fixed amounts, the Newton second law of motion, [8], $\boldsymbol{F} = d\boldsymbol{p}/dt = d\left(m\mathbf{v}/\sqrt{1-\beta^2}\right)/dt = \left(m/\sqrt{1-\beta^2}\right)\left(d\mathbf{v}/dt\right) = \left(m/\sqrt{1-\beta^2}\right)\left(v^2/r\right)\left(\boldsymbol{r}/r\right)$ and Coulomb's the law of attraction, [8], $qQ/4\pi\varepsilon_0 r^2$, are equalized; we take that *q* and *Q* have opposite sign and *q* is negative:

$$\frac{mv^2}{r\sqrt{1-\beta^2}} = -\frac{qQ}{4\pi\varepsilon_0 r^2}\,; \tag{3}$$

here ε_0 is electric constant. From Eq. (3) it follows (with $v/c = \beta$):

$$r = -\frac{qQ}{4\pi\varepsilon_0 mc^2}\frac{\sqrt{1-\beta^2}}{\beta^2} \,. \tag{4}$$

The kinetic energy of the moving body is [8]

$$K = \frac{mc^2}{\sqrt{1-\beta^2}} - mc^2 \,, \tag{5}$$

and its potential energy [8] , using Eq. (4), is

$$U = \frac{qQ}{4\pi\varepsilon_0 r} = qV_U = -\frac{mc^2}{\sqrt{1-\beta^2}}\beta^2 \,, \tag{6}$$

here $V_U = Q/\left(4\pi\varepsilon_0 r\right)$ is electric potential [8], also known as the Coulomb potential.

The total mechanical energy *W* of the observed system is the sum of previously determined kinetic energy, *K*, and the potential energy, *U* [8]:

$$W = K + U = -mc^2\left(1-\sqrt{1-\beta^2}\right). \tag{7}$$

To keep this system stationary (*meaning it no longer emits or absorbs energy*), it has by law of conservation of energy emitted exactly such a large amount of energy $\Delta W = W - W_0 = -mc^2\left(\sqrt{1-\beta_0^2} - \sqrt{1-\beta^2}\right) = E_{em}$, with the opposite sign ΔW and E_{em}; namely, the energy lost by the atom, ΔW, gets to the emitted photon, E_{em}. For simplicity, we will take that initial velocity is always zero, *i.e.*, $\beta_0 = 0$. In this way, we calculated the amount of electromagnetic energy emitted,

$$E_{em} = -W = mc^2\left(1-\sqrt{1-\beta^2}\right) = -qV_{em}\,, \tag{8}$$

where V_{em} is the potential difference (voltage) through which passes the body charged with charge q to get the same energy as the electromagnetic energy E_{em} emitted (as we have said, the charge q is negative; $q = -ze$, z = 1, 2, 3, …, e is the elementary charge, while $Q = +Ze$, Z = 1, 2, 3, …).

From Eq. (8), $E_{em} = mc^2\left(1-\sqrt{1-\beta^2}\right)$, we can express $\sqrt{1-\beta^2} = \left(1-E_{em}/mc^2\right)$ and $\beta^2 = 2E_{em}\left(1-E_{em}/2mc^2\right)/mc^2$, and we include these two in the Eq. (4); we get

$$r = -\frac{qQ}{8\pi\varepsilon_0 E_{em}}\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}\,, \tag{9}$$

and from here

$$E_{em} = -\frac{1}{2}\frac{qQ}{4\pi\varepsilon_0 r}\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}\,. \tag{10}$$

With $E_{em} = -qV_{em}$ and $\varepsilon_0 = 1/\mu_0 c^2$, from Eq. (10) we get two solutions for V_{em}, from infinite distance to the first orbit:

$$V_{em1} = \frac{c^2\left(\mu_0 qQ - 8m\pi r + \sqrt{\mu_0^2 q^2 Q^2 + 8^2 m^2 \pi^2 r^2}\right)}{8\pi q r}\,, \tag{11}$$

and from the first orbit to a distance equal to zero:

$$V_{em2} = \frac{c^2\left(\mu_0 qQ - 8m\pi r - \sqrt{\mu_0^2 q^2 Q^2 + 8^2 m^2 \pi^2 r^2}\right)}{8\pi q r}\,, \tag{12}$$

while from equation (9) a unique solution for r arises:

$$r = \left|\frac{\mu_0 c^2 Q}{8\pi V_{em}}\frac{1+\dfrac{qV_{em}}{mc^2}}{1+\dfrac{qV_{em}}{2mc^2}}\right|. \tag{13}$$

So, for example, with measured [9] V_{em} = 13.59843449 V, ($q = -ze = -e$; $Q = Ze = e$), from Eq. (13) we calculate the radius of the first Hydrogen orbit, r_{H} = 5.294526279 × 10^-11^ m, and with V_{em} = 54.417765 V, ($q = -ze = -e$; $Q = Ze = 2e$), we get the radius of the first orbit of Helium, r_{He} = 2.645988600 × 10^{-11} m, and with V_{em} = 1362.19915 V, ($q = -ze = -e$; $Q = Ze = 10e$), we get the first orbit of Neon, r_{Ne} = 5.278386334 × 10^{-12} m, while for Darmstadtium, V_{em} = 204400 V, ($q = -ze = -e$; $Q = Ze = 110e$), the first orbit is r_{Ds} = 2.905992468 × 10^{-13} m.

To create an electromagnetic wave, as stated, which comes from the observed structure, this structure in some way enables its broadcasting. Let's examine the existence of the simple harmonic *LC* oscillator in that structure. The natural frequency *f* of the *LC* oscillator is [8].

$$f = \omega/2\pi = 1/\left(2\pi\sqrt{LC}\right). \tag{14}$$

The electromagnetic energy E_{em} in the observed structure, which can be an atom too, is the energy of the observed *LC* oscillator [8].

$$E_{em} = \frac{1}{2}\frac{\Theta^2}{C} = \frac{1}{2}LI^2 = \frac{1}{2}L\omega^2\Theta^2; \tag{15}$$

Θ is here the maximum charge on the condenser whose capacitance is *C*. The correlation between the frequency *f* and the angular frequency ω is in Eq. (14), $\omega = 2\pi f = 1/\sqrt{LC}$, and from this last expression comes the inductance *L*:

$$L = 1/\left(\omega^2 C\right) = 1/\left(4\pi^2 f^2 C\right). \tag{16}$$

When we equate Eqs. (10, 15) then we get:

$$-\frac{1}{2}\frac{qQ}{4\pi\varepsilon_0 r}\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} = \frac{1}{2}\frac{\Theta^2}{C}. \tag{17}$$

In only one Eq. (17) there are two unknowns, $C = x$ and $\Theta = y$. It would be useful to establish another independent equation. If that is not possible then we can try to solve this equation in another way. When the number of unknowns is greater than the number of equations then the solution is searched by Diophantine equations [10]. In order to solve the Eq. (17) we describe it in algebraic form:

$$ax + by^2 = 0, \tag{18}$$

there are *a* and *b* coefficients of Eq. (18):

$$a = \frac{1}{4\pi\varepsilon_0 r}; \quad b = \frac{1}{qQ\dfrac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}}. \tag{19}$$

Since coefficients *a* and *b* are not integers, as Diophantine equations require, the solution should be sought in another way. One set of solutions obviously is

$$C = 4\pi\varepsilon_0 r, \tag{20}$$

and

$$\Theta^2 = -qQ\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}. \tag{21}$$

Eq. (17) will now be written in a different way. It is a path to show that electromagnetic energy in *LC* oscillator always is proportional to its natural frequency *f*, Eq. (14). Namely, according to the Eq. (15) is:

$$\begin{aligned} E_{em} &= \frac{1}{2}\frac{\Theta^2}{C} = \frac{1}{2}\frac{\pi}{\pi}\frac{\Theta^2}{\sqrt{C}\sqrt{C}}\frac{\sqrt{L}}{\sqrt{L}} \\ &= \pi\sqrt{\frac{L}{C}}\Theta^2\frac{1}{2\pi\sqrt{LC}} \\ &= \pi Z_{LC}\Theta^2 f \\ &= \pi\sqrt{\frac{L}{C}}\left(-qQ\frac{1-E_{\mathrm{em}}/mc^2}{1-E_{\mathrm{em}}/2mc^2}\right)f = Af. \end{aligned} \tag{22}$$

Here *A* is the *action* of the electromagnetic *LC* oscillator; it is the quotient of the electromagnetic energy E_{em} to the natural frequency *f* of the *LC* oscillator:

$$A = \frac{E_{em}}{f} = -\pi\sqrt{\frac{L}{C}}qQ\frac{1-E_{\mathrm{em}}/mc^2}{1-E_{\mathrm{em}}/2mc^2}. \tag{23}$$

We have the capacitance of *LC* oscillator mathematically chosen in Eq. (20), *i.e.*, $C = 4\pi\varepsilon_0 r$. The *LC* oscillator inductance L is thereby also being chosen in accordance with Eq. (16), $L=1/\left(4\pi^2 f^2 C\right)$. So, the characteristic impedance of LC oscillator, which impedance can be expressed as a γ multiplier with vacuum impedance $Z_0=\sqrt{\mu_0/\varepsilon_0}=\mu_0 c$, is

$$\begin{aligned} Z_{LC} &= \sqrt{\frac{L}{C}} = \gamma Z_0 = \gamma\ \mu_0\ c \\ &= \sqrt{\frac{1/\left(4\pi^2 f^2 C\right)}{C}} \\ &= \sqrt{\frac{1}{4\pi^2 f^2 C^2}} = \frac{1}{2\ \pi\ f\ C}, \end{aligned} \tag{24}$$

whereby $\gamma = Z_{LC}/Z_0$ is the *impedances ratio* [5], and when we put the result from Eq. (24) in Eq. (23) we get:

$$A=-\pi\frac{1}{2\ \pi\ f\ C}qQ\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} \quad . \tag{25}$$

Now we can include in Eq. (25) the amount of C from Eq. (20):

$$A=-\frac{1}{8\ f\pi\ \varepsilon_0\ r}qQ\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}. \tag{26}$$

If we include now r, from Eq. (4) in Eq. (26), we get:

$$\begin{aligned} A &= -\frac{qQ\dfrac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}}{8\ f\pi\ \varepsilon_0\left(-\dfrac{qQ}{4\pi\varepsilon_0 mc^2}\dfrac{\sqrt{1-\beta^2}}{\beta^2}\right)} \\ &= \frac{mc^2\beta^2}{2f\sqrt{1-\beta^2}}\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}. \end{aligned} \tag{27}$$

Let's just note now one detail; namely, the Eq. (27) is not directly dependent on the charge. Later [after Eq. (47)] we will return to Eq. (27) and show that term $mc^2\beta^2/\left(2f\sqrt{1-\beta^2}\right)$ is actually a constant.

3. Lecher Line as Model of an *LC* Atom Oscillator

To clarify relationship between β and f in Eq. (27), in term $mc^2\beta^2/\left(2f\sqrt{1-\beta^2}\right)$, we will use a known source of electromagnetic energy, for example a Lecher transmission line (Figure 1), where the physical relations of the *LC* oscillator are entirely clear. Specifically, we assume Maxwell's equations also apply to the atom. The equations of Lecher's lines are completely in line with Maxwell's equations. That is why Lecher's line in terms of electromagnetic oscillations can be used as part of the atomic model. Once we clarify these term $mc^2\beta^2/\left(2f\sqrt{1-\beta^2}\right)$, after Eq. (47), then we will return to Eq. (27). This, in effect, means that we will use the Lecher line as a model of the oscillatory *LC* oscillator in the atom. Note here that this could be some other transmission line. Lecher line has been chosen as a model because of its simplicity.

Lecher line is twin-lead transmission line consisting of a pair of ideal conductive nonmagnetic parallel wires of diameter 2ρ, separated by δ (we tag $\delta/\rho=\chi$), whose length is ζ, situated in space with permittivity ε_0 and permea-

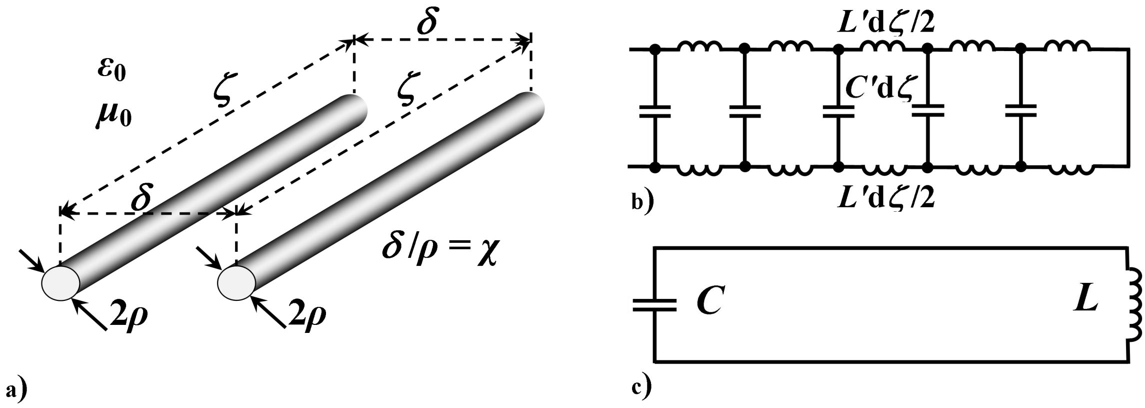

Figure 1. a) A section of Lecher's line that is long ζ; it is a twin-lead transmission line consisting of pair of ideal conductive nonmagnetic wires of diameter 2ρ, separated by δ, situated in space with permittivity ε_0 and permeability μ_0.
b) Lecher's line presented by an infinite number of extremely small uniformly distributed capacitors, with capacitance $C'\mathrm{d}\zeta$, and with equals such inductors, with inductance $L'\mathrm{d}\zeta$.
c) All mentioned capacitors are collected at the open end of the line, denoted by C, and all mentioned inductors are collected on its short-circuited end, and denoted by L, resulting in an LC circuit.

bility μ_0. Let's repeat the procedure for the Lecher line starting with Eq. (24). Capacitance per unit length C' of Lecher line is [11].

$$C' = \pi\varepsilon_0 \Big/ \ln\left(\chi/2 + \sqrt{(\chi/2)^2 - 1}\right), \tag{28}$$

and inductance per unit length L' of Lecher line is [11],

$$L' = \mu_0 \left(\ln\chi + 1/4\right)/\pi . \tag{29}$$

So, the characteristic impedance of the Lecher line is

$$\begin{aligned} Z_{LC} &= \sqrt{\frac{L}{C}} = \sqrt{\frac{L'\,\mathrm{d}\zeta}{C'\,\mathrm{d}\zeta}} = \sqrt{\frac{L'}{C'}} \\ &= \sqrt{\frac{\mu_0}{\varepsilon_0}}\,\frac{\sqrt{\left[\ln\left(\frac{\chi}{2} + \sqrt{\left(\frac{\chi}{2}\right)^2 - 1}\right)\right]\left(\ln\chi + \frac{1}{4}\right)}}{\pi} \\ &= \sqrt{\frac{\mu_0}{\varepsilon_0}}\,\frac{\sigma(\chi)}{\pi} \;, \end{aligned} \tag{30}$$

while

$$\sigma(\chi) = \sqrt{\left[\ln\left(\frac{\chi}{2} + \sqrt{\left(\frac{\chi}{2}\right)^2 - 1}\right)\right]\left(\ln\chi + \frac{1}{4}\right)} \tag{31}$$

is the *structural coefficient of Lecher line*.

Take the segment of equation (22), $\Theta^2/(2C) = \pi Z_{LC}\Theta^2 f$, and include in it Eq. (20) (*i.e.*, $C = 4\pi\varepsilon_0 r$), and Eq. (30) [*i.e.*, $Z_{LC} = \sqrt{\mu_0/\varepsilon_0}\,\sigma(\chi)/\pi$], we get the natural frequency of the oscillatory circuit. This frequency depends only on the parameters of the oscillatory circuit and the properties of the space in which that circuit is located:

$$f = \frac{1}{8\pi\sqrt{\varepsilon_0\mu_0}\ \sigma(\chi) r}. \tag{32}$$

4. Structural Constant of all Atoms

Let us notice precisely here that the natural frequency *f* in Eq. (32) depends only on the properties of the space, *i.e.*, ε_0, and μ_0, and on the spatial parameters, *i.e.*, χ, in accordance with Eq. (31) and *r*. The Eqs. (27, 32) are not dependent on charges or any charge product. Thus in accordance with Eq. (22) neither the energy $E_{em} = Af$, does not explicitly depend on the charge, because neither *A* nor *f* explicitly depend on the charge. However, if the radius *r* from Eq. (9) is entered in equation (32) we get:

$$f = -\frac{E_{em}}{\sqrt{\mu_0/\varepsilon_0}\ \sigma(\chi) qQ}\frac{1-E_{em}/2mc^2}{1-E_{em}/mc^2}. \tag{33}$$

Here, the charge appears as a variable in the form of product qQ . To avoid this, and realize the frequency *f* independent on the charge as variables, should be taken to be worth $\sigma(\chi)qQ = -\sigma(\chi)zZe^2$ = Const.1, actually, since e^2 is constant in itself, $-\sigma(\chi)zZ = \text{Const.2} = s_0^2$, with, as stated above, $q = z(-e) = -ze$ and $Q = Z(+e) = Ze$, where elementary charge *e* is used only as measure of the charge, but not as a variable; it should be kept in mind that at the beginning we said that the charge *q* would be considered negative, *i.e.*, $q = -ze$, and as such it is used, that's why $\sqrt{-1} = \mathbf{i}$, the factors *z* and *Z* theoretically do not necessarily have to be an integer:

$$s_0 = \left|\sqrt{\sigma(\chi)(zZ)}\right| = \text{Const.3} = \text{constant}. \tag{34}$$

This size s_0 is a constant [12]; the higher is *z* or *Z*, the smaller is $\sigma(\chi)$ [12], and vice versa, their product $\sigma(\chi)(zZ)$ is always the same [12]. These factors *z* and *Z* basically determine the system being observed. We say *basically* because the actual system is determined even with orbit parameters (*n*; which we will see later) that are not expressed in Eq. (34), but those parameters are hidden in the members tagged with E_{em} . It should be said, for the realization of the oscillator must be some charge present, but the amount of natural frequencies of these oscillators must not depend on the amount of these charges as a variable. So, from Eq. (33) and (34) we get:

$$f = \frac{E_{em}}{\sqrt{\mu_0/\varepsilon_0}\ e^2 s_0^2}\frac{1-E_{em}/2mc^2}{1-E_{em}/mc^2}. \tag{35}$$

It's in vacuum $1/\sqrt{\mu_0\varepsilon_0} = c$ and $\sqrt{\mu_0/\varepsilon_0} = \mu_0 c$, so from Eqs. (23, 30, 34) follows:

$$\begin{aligned} A &= -\pi\sqrt{\frac{L}{C}}qQ\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} \\ &= -\pi\sqrt{\frac{\mu_0}{\varepsilon_0}}\frac{\sigma(\chi)}{\pi}qQ\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} \\ &= \sqrt{\frac{\mu_0}{\varepsilon_0}}\left[\sigma(\chi)zZ\right]e^2\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} \\ &= \mu_0 c e^2 s_0^2\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2} = A_0\frac{1-E_{em}/mc^2}{1-E_{em}/2mc^2}. \end{aligned} \tag{36}$$

Here is

$$A_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} e^2 s_0^2 = \mu_0 c e^2 s_0^2 \tag{37}$$

the maximum of action of *LC* oscillator, *i.e.*, the action by $f = 0$ respectively by $E_{em} = 0$. From Eqs. (35, 37), we get

$$E_{em} = A_0 f \frac{1 - E_{em}/mc^2}{1 - E_{em}/2mc^2}, \tag{38}$$

and from Eq. (38) comes

$$E_{em} = A_0 f + mc^2 - \sqrt{(A_0 f)^2 + (mc^2)^2} \tag{39}$$

and since Eq. (22) $E_{em} = Af$, then

$$A = A_0 + mc^2/f - \sqrt{A_0^2 + (mc^2/f)^2} \tag{40}$$

Duane-Hunt's law in extended form [13] comes from Eq. (38), using Eq. (8), *i.e.*, $E_{em} = -qV_{em}$:

$$f = -\frac{qV_{em}}{A_0} \frac{1 + qV_{em}/2mc^2}{1 + qV_{em}/mc^2}. \tag{41}$$

Namely, taking into account Eqs. (8, 36), Eq. (41) can be written as

$$f = -\frac{qV_{em}}{A}, \tag{42}$$

while the original form of Duane-Hunt's Law [14] is $f = eV_{em}/h$; here h is Planck's constant, which is replaced here by A, *i.e.*, h=A.

Do we include $qV_{em} = -mc^2\left(1 - \sqrt{1-\beta^2}\right)$, from Eq. (8), in the Eq. (41), we get [using Eq. (37)]:

$$f = \frac{mc^2}{2A_0} \frac{\beta^2}{\sqrt{1-\beta^2}} = \frac{f_0}{2} \frac{\beta^2}{\sqrt{1-\beta^2}}, \tag{43}$$

here, respectively, f_0 and τ_0 are the *elementary frequency* and the *elementary time of one electron in an atom*:

$$f_0 = \frac{mc^2}{A_0} = \frac{mc}{\mu_0 e^2 s_0^2} = 1.23525211244 \times 10^{20}\,\text{Hz},$$

$$\tau_0 = \frac{\beta^2}{2f\sqrt{1-\beta^2}} = \frac{A_0}{mc^2} = \frac{1}{f_0} = \frac{\mu_0 e^2 s_0^2}{mc} = 8.09551337682 \times 10^{-21}\,\text{s}. \tag{44}$$

The Eq. (43), according to the Eqs. (6, 44), gives:

$$f = -\frac{1}{2}\frac{U}{A_0} = -\frac{1}{2}\frac{U}{\mu_0 c e^2 s_0^2}, \tag{45}$$

and this leads to the *Ritz's combination principle* [15], $f_{ki} = \left[E_{em(k)} - E_{em(i)}\right]/h$, which in our case reads

$$f_{ki} = \left(-\tfrac{1}{2}U_k + \tfrac{1}{2}U_i\right)/A_0, \tag{46}$$

where $U_k > U_i$. From Eq. (43) β also can be written as

$$\beta = \sqrt{2}\sqrt{\sqrt{\left(\frac{f}{f_0}\right)^4 + \left(\frac{f}{f_0}\right)^2} - \left(\frac{f}{f_0}\right)^2} \ . \tag{47}$$

Now we have enough elements to go back and complete Eq. (27). Namely, from Eqs. (43, 44), the unknown relationship in Eq. (27) , $mc^2\beta^2 \big/ \left(2f\sqrt{1-\beta^2}\right)$, now reads as A_0, *i.e.*,

$$\frac{mc^2\beta^2}{2f\sqrt{1-\beta^2}} = A_0; \qquad \frac{\beta^2}{f\sqrt{1-\beta^2}} = \frac{2A_0}{mc^2} = 2\tau_0 = T_0 = 1.61910267536\times10^{-20}\,\text{s} \ . \tag{48}$$

So, include it in Eq. (27), we get:

$$A = A_0 \frac{1 - E_{em}/mc^2}{1 - E_{em}/2mc^2} = \mu_0 c e^2 s_0^2 \frac{1 - E_{em}/mc^2}{1 - E_{em}/2mc^2}. \tag{49}$$

We see that we get the same result as the one at the end of the Eq. (36), what has to be so, and by the bypass we get in Eq. (47), *i.e.*, the relation between β and f, which is not entirely simple.

5. Discretization of the States in the Atom

Structural constant of the atom s_0 can be calculated in several ways [12, 16, 17]. Now we will see a *new method*. The momentum of the electromagnetic wave is defined as the photon momentum [15]

$$p_{em} = \frac{E_{em}}{u_{em}} \ , \tag{50}$$

whereby

$$u_{em} = c = \lambda f \tag{51}$$

is phase velocity, and λ is wavelength of electromagnetic wave. Using Eq. (42), *i.e.*, $-qV_{em} = Af$, and taking into account Eq. (8), $E_{em} = -qV_{em}$, and Eq. (51), $u_{em} = \lambda f$, Eq. (50) takes the form of de Broglie's expression for the photon momentum [15]:

$$p_{em} = \frac{Af}{\lambda f} = \frac{A}{\lambda} \ . \tag{52}$$

The photon momentum, in accordance with the law of conservation of momentum [8], and with Eq. (2), is equal in amount to the momentum of the electron. So Eq. (52) becomes:

$$\frac{A}{\lambda} = mv\big/\sqrt{1-\beta^2} = mc\beta\big/\sqrt{1-\beta^2} \ . \tag{53}$$

At least two independent physical phenomena appear in the atom, which after the transition process enable atomic formation. One is the uniform circular motion of the electron around the nucleus, and the second are the oscillations of the electromagnetic energy generated within the atom. The time of one complete revolution of the electron around the nucleus (the so-called period) is

$$T_\phi = \frac{2r\pi}{v} = \frac{1}{\phi}, \tag{54}$$

ϕ is the frequency of the rotation of body charged with the charge q. Entirely different oscillation period, period of electromagnetic oscillation, T_{em} , is

$$T_{em} = \frac{1}{f} \ . \tag{55}$$

The multiplication of the Eq. (54), with the frequency f of electromagnetic oscillations, gives

$$\frac{2r\pi f}{v} = \frac{f}{\phi}. \tag{56}$$

Using Eq. (45), $f = -U/(2A_0)$, and Eq. (6), $U = qQ/(4\pi\varepsilon_0 r)$, and taking into account that $\varepsilon_0 = 1/(\mu_0 c^2)$, and Eq. (37), $A_0 = \mu_0 c e^2 s_0^2$, from Eq. (56) follows:

$$\frac{f}{\phi} = -\frac{qQ}{4\varepsilon_0 A_0 v} = -\frac{qQc}{4ve^2 s_0^2}. \tag{57}$$

Electromagnetic energy in the atom can exist as a standing wave. The standing wave does not transmit the energy, but it sways existing energy. If the natural frequency of the *LC* oscillator is *f*, the *active power* (in the index marked with "*AcP*") of the standing wave oscillates with dual frequency [18], $f_{AcP} = 2f$. Thesis: *In order for the electromagnetic standing wave to exist in the atom, there must be a mutual synchronization relationship between the frequency of electron motion around the nucleus and the frequency of oscillation of electromagnetic energy in the atom* (it should be noted here that other integer relations between these two phenomena are theoretically possible):

$$f_{AcP} = n\,\phi, \tag{58}$$

where *n* is one of the whole numbers 1, 2, 3, … . Both above mentioned phenomena in respect of synchronization are equal, so also applies

$$\phi = n\, f_{AcP}. \tag{59}$$

The two Eqs. (58, 59), can be written as one expression:

$$f_{AcP} = n^{\pm 1}\phi, \tag{60}$$

or, because of $f_{AcP} = 2f$,

$$f = \frac{1}{2} n^{\pm 1}\phi. \tag{61}$$

From Eqs. (57, 61) we obtain the velocity for discrete states:

$$v_n = -\frac{c}{2n^{\pm 1} s_0^2}\frac{qQ}{e^2} = -\frac{c}{2n^{\pm 1} s_0^2}\frac{(-ze)(+Ze)}{e^2} = \frac{czZ}{2n^{\pm 1} s_0^2}. \tag{62}$$

From Eq. (61), after connecting $f = f_n$ and $\phi = \phi_n$, follows for frequencies in discrete states:

$$f_n = \frac{1}{2} n^{\pm 1}\phi_n. \tag{63}$$

From Eq. (62), taking into account $v_n = c\beta_n$, we obtain:

$$\beta_n = -\frac{1}{n^{\pm 1}}\frac{qQ}{2s_0^2 e^2} = \frac{zZ}{2n^{\pm 1} s_0^2}. \tag{64}$$

We can express β from Eq. (8), $\beta = \sqrt{-qV_{em}\left(2 + qV_{em}/mc^2\right)/mc^2}$, and equate this β with that in the expression (64):

$$\sqrt{-\frac{qV_{em}}{mc^2}\left(2 + \frac{qV_{em}}{mc^2}\right)} = -\frac{1}{n^{\pm 1}}\frac{qQ}{2s_0^2 e^2}. \tag{65}$$

From Eq. (65), we get structural constant s_0 determined by the aforementioned *new method*, which proves to be the most accurate:

$$s_0 = -\frac{\mathbf{i}\sqrt{\dfrac{qQ}{e^2}}}{\sqrt{2n^{\pm1}\sqrt{1-\left(1+\dfrac{qV_{em\,(n)}}{mc^2}\right)^2}}} \tag{66}$$

Two $V_{em\,(n)}$ solutions we get from Eq. (66):

$$V_{em1\,(n)} = \frac{mc^2}{ze}\left(1-\sqrt{1-\left(\frac{1}{n^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}\right), \tag{67}$$

and

$$V_{em2\,(n)} = \frac{mc^2}{ze}\left(1+\sqrt{1-\left(\frac{1}{n^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}\right). \tag{68}$$

The solution in Eq. (67) is for the lower (ionization) voltages (namely, for q=-e, than to 510998.946 V), and the solution in Eq. (68) is for the higher (ionization) voltages (so, for q=-e, than to 1021997.813 V). We can see that $V_{em1\,(n)} + V_{em2\,(n)} = -2mc^2/q$. Let us introduce now one abbreviation. Namely, instead of $\sqrt{1-\beta^2}$, in accordance with Eq. (64), we put Γ_n (symbol of the field of Discrete Physics):

$$\Gamma_n = \sqrt{1-\left(\frac{1}{n^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}\ . \tag{69}$$

By incorporating Eqs. (64, 69) in Eq. (4), using $q=-ze$, $Q=Ze$, $\varepsilon_0 = 1/(\mu_0 c^2)$, it yields a radius of electron orbit:

$$r_n = \left(n^{\pm1}\right)^2 \frac{\mu_0 e^2 s_0^4}{\pi mzZ}\Gamma_n\,. \tag{70}$$

So for example, repeat the calculation as we did after Eq. (13), but now in a different way; we calculate the radius of the first Hydrogen orbit. There we should measure V_{em} and used 6 more parameters; *i.e*., *z, Z, e,* μ_0 *, m, c*; while now, instead of measuring V_{em}, we have the computational value s_0 and we need, also, 6 additional parameters; 5 of these parameters are the same as before, *i.e*., *z, Z, e,* μ_0 *, m*, and instead of the parameter *c*, we now use the number *n*. We get the same result without measuring V_{em} and we do not have to use the speed of light. Let's show this using equation (70). For the first orbit of Hydrogen ($z=1$, $Z=1$, n=1), r_{H} = 5.294526279 × 10^{-11} m, and we get the radius of the first orbit of Helium ($z=1$, $Z=2$, $n=1$), r_{He} = 2.647051780 ×10^{-11} m. Also we get the first orbit of Neon ($z=1$, $Z=10$, $n=1$), r_{Ne} = 5.280558679 × 10^{-12} m, while for Darmstadtium the first orbit is ($z=1$, $Z=110$, $n=1$), r_{Ds} = 2.871955104 × 10^{-13} m. So, by introducing s_0 we avoided the measurements of V_{em} and got all the same results as before. The resulting deviations are most commonly inside ±0.1%and at Darmstadtium (Z = 110) reach a maximum of 1.17%. This difference probably stems from the accuracy of the measurements at such a large V_{em}.

From Eq. (6) it has been generated the Coulomb potential, $V_U = Q/(4\pi\varepsilon_0 r)$, and from here, using Eq. (69), we get (with $q=-ze$, $Q=Ze$):

$$V_{U(n)} = \frac{mc^2 zZ^2}{4\left(n^{\pm1}\right)^2 e\ s_0^4\Gamma_n}\,. \tag{71}$$

Let's now calculate the *impedances ratio* γ . We start from Eq. (24):

$$Z_{LC} = \sqrt{\frac{L}{C}} = \gamma Z_0 = \gamma\ \mu_0\ c = \frac{1}{2\,\pi\, f\, C}\,. \tag{72}$$

From here we get γ:

$$\gamma = \frac{\sqrt{L/C}}{\mu_0\ c} = \frac{1}{2\,\pi\ f\ C\ \mu_0\ c}\,. \tag{73}$$

Now we have to determine C and f. So we use Eq. (20), $C = 4\pi\varepsilon_0 r$, and Eq. (45), $f = -U\big/\left(2\mu_0 c e^2 s_0^2\right)$, than from Eq. (73) we get:

$$\gamma = -\frac{e^2 s_0^2}{4\,\pi^2\ \varepsilon_0\ r\,U}\,. \tag{74}$$

Using Eq. (6); $U = qQ\big/\left(4\pi\varepsilon_0 r\right)$, we get from Eq. (74):

$$\gamma = -\frac{e^2 s_0^2}{\pi\ q\,Q}\,. \tag{75}$$

If we use $q = -ze$ and $Q = +Ze$, from Eq. (75) we get:

$$\gamma = \frac{s_0^2}{\pi\ z\ Z}\,. \tag{76}$$

From Eq. (72), $\gamma = \sqrt{L/C}\big/\left(\mu_0\ c\right)$, and Eq. (75), $\gamma = s_0^2\big/\left(\pi z Z\right)$, derives

$$s_0 = \sqrt{\frac{zZ\pi\sqrt{L/C}}{\mu_0 c}}\,. \tag{77}$$

In Eq. equation (77) one of its parts, *i.e.*, $zZ\pi\sqrt{L/C}$, is equal $\mu_0 c s_0^2$, which corresponds in amount to von Klitzing's constant R_{K}. Deeper connection with the von Klitzing constant needs to be investigated.

If we equate Eq. (41), for the frequencies, $f = -\left[qQ\left(1 + qV_{em}\big/2mc^2\right)\right]\Big/\left[A_0\left(1 + qV_{em}\big/mc^2\right)\right]$, and Eq. (45); $f = -U\big/\left(2\mu_0 c e^2 s_0^2\right)$, and then use Eq. (6); $U = -mc^2\beta^2\big/\sqrt{1-\beta^2}$ and Eq. (36); $A_0 = \mu_0 c e^2 s_0^2$, we can calculate the (ionization) voltage V_{em} depending on β:

$$V_{em} = -\frac{mc^2}{q}\,\frac{\beta^2 mc^2 + 2\sqrt{1-\beta^2}\,qQ}{\beta^2 mc^2 + \sqrt{1-\beta^2}\,qQ}\,. \tag{78}$$

If $\beta = 1$ the (ionization) voltage is maximum, and is: $V_{em} = V_{\max} = -mc^2\big/q$.

Now from Eq. (66) we can calculate minimum of $n^{\pm 1}$, $n_{\min}^{\pm 1}$, and maximum of Z, $Z_{\max}$. So, if we take $z = 1$ and Z=1, it comes out
$n_{\min}^{\pm 1} = -qQ\big/\left(2e^2 s_0^2\right) = -\left(-ze\right)\left(+Ze\right)\big/\left(2e^2 s_0^2\right) = 1\big/\left(2s_0^2\right)$.

Similarly, if we take $z = 1$ and $n^{\pm 1} = 1$, we get from Eq. (66) the highest atomic number $Z_{\max} = -2en^{\pm 1} s_0^2\big/q = -2es_0^2\big/\left(-e\right) = 2s_0^2$.

If we introduce Eqs. (64, 69) into Eq. (6), we get the potential energy of the system:

$$U_n = -\frac{mc^2 q^2 Q^2}{4\left(n^{\pm 1}\right)^2 e^4 s_0^4\sqrt{1-\beta_n^2}} = -\frac{mc^2 z^2 Z^2}{4\left(n^{\pm 1}\right)^2 s_0^4 \varGamma_n}\,. \tag{79}$$

The kinetic energy of the system is derived from Eqs. (5, 64):

$$K_n = mc^2\left(\frac{1}{\sqrt{1-\beta_n^2}}-1\right) = mc^2\left(\frac{1}{\Gamma_n}-1\right). \tag{80}$$

The mechanical energy of the system W, according to equation (7), then amounts:

$$W_n = mc^2\left(\sqrt{1-\beta_n^2}-1\right) = mc^2\left(\Gamma_n - 1\right). \tag{81}$$

From there, the energy of the system, $E_{em(n)} = -W_n = -qV_{em(n)}$, according to the equation (8), is:

$$E_{em(n)} = -qV_{em(n)} = -mc^2\left(\sqrt{1-\beta_n^2}-1\right) = mc^2\left(1-\Gamma_n\right). \tag{82}$$

The electromagnetic frequency is obtained from Eqs. (45, 79):

$$f_n = \frac{mcq^2Q^2}{8\left(n^{\pm 1}\right)^2 \mu_0 e^6 s_0^6 \sqrt{1-\beta_n^2}} = \frac{mcz^2Z^2}{8\left(n^{\pm 1}\right)^2 \mu_0 e^2 s_0^6 \Gamma_n}. \tag{83}$$

From Eqs. (27, 64, 81, 83), we obtain the action A_n of the electromagnetic oscillator:

$$A_n = \mu_0 ce^2 s_0^2 \frac{2\sqrt{1-\beta_n^2}}{1+\sqrt{1-\beta_n^2}} = \mu_0 ce^2 s_0^2 \frac{2\Gamma_n}{1+\Gamma_n}. \tag{84}$$

The capacitance C is derived from Eqs. (20, 70):

$$C_n = -\frac{\left(2n^{\pm 1}e^2 s_0^2\right)^2}{mc^2 qQ}\sqrt{1-\beta_n^2} = \frac{\left(2n^{\pm 1}e\, s_0^2\right)^2}{mc^2 zZ}\Gamma_n. \tag{85}$$

The inductance L can be expressed from equation (16) with the help of Eqs. (83, 85):

$$L_n = -\frac{\left(2n^{\pm 1}\mu_0 e^4 s_0^4\right)^2}{m\pi^2 q^3 Q^3}\sqrt{1-\beta_n^2} = \frac{\left(2n^{\pm 1}\mu_0 e s_0^4\right)^2}{m\pi^2 z^3 Z^3}\Gamma_n. \tag{86}$$

For the first orbit of a hydrogen atom ($n = z = Z = 1$) it is worth: C_1=5.890954960 × 10^{-21} F, L_1=3.979183560 × 10^{-13} H, $\sqrt{L_1/C_1}$ =8218.719068068 Ω, $s_0 = \sqrt{zZ\pi\sqrt{L_1/C_1}/(\mu_0 c)}$ = 8.278691910.

In order to verify the previous equations, add Eqs. (85, 86) to Eq. (77). We get structural constant s_0 . So, everything is correct.

6. The Numerical Value of the Structural Constant

Derived formulas do not allow direct calculation of structural constant s_0 . So we have to do at least one measurement. This can be best done through Eq. (66), thanks to the precision of NIST data [9], [https://www.nist.gov/pml/atomic-spectra-database; $V_{em(1)} = 13.598\,434\,49\text{ V}$, $n^{\pm 1} = 1$, $z = 1$, $Z = 1$]:

$$s_0 = -\frac{\mathbf{i}\sqrt{\frac{qQ}{e^2}}}{\sqrt{2n^{\pm 1}\sqrt{1-\left(1+\frac{qV_{em}}{mc^2}\right)^2}}} = \frac{\sqrt{zZ}}{\sqrt{2n^{\pm 1}\sqrt{1-\left(1-\frac{eV_{em}}{mc^2}\right)^2}}} = \sqrt{\frac{1}{2\sqrt{1-\left(1-\frac{eV_{em1(1)}}{mc^2}\right)^2}}}$$
$$= 8.278\,691\,910\,036. \tag{87}$$

Table 1. Structural constant of atoms s_0 calculated on the basis of ionization potential according to NIST's data*

Chemical symbol of the element	Atomic number Z	Atomic number Eq. (68), neutron[a]	Ionization potential [Volt]		Structural constant s_0 [Dimensionless Number], Eq. (87)
n^0, H	1	712207.8053 V	13.598 434 49 [b]	←→	8.278 691 910 036
He	2		54.417 7650 [b]	←→	8.277 860 595 602
Li	3		122.454 3581 [b]	←→	8.277 755 226 469
Be	4		217.718 5843 [b]	←→	8.277 739 533 105
B	5		340.226 020 [b]	←→	8.277 739 896 484
C	6		489.993 194 [b]	←→	8.277 757 231 963
N	7		667.046 116 [b]	←→	8.277 771 755 296
O	8		871.409 88 [b]	←→	8.277 791 688 375
F	9		1 103.117 47 [b]	←→	8.277 812 276 144
Ne	10		1 362.199 15 [b]	←→	8.277 842 618 038
Ca	20		5 469.8615 [b]	←→	8.278 203 152 859
Zn	30		12 388.929 [b]	←→	8.278 637 976 575
Zr	40		22 236.677 [b]	←→	8.279 106 265 650
Sn	50		35 192.39 [b]	←→	8.279 610 860 584
Nd	60		51 515.58 [b]	←→	8.280 166 600 276
Yb	70		71 574.80 [b]	←→	8.280 846 679 237
Hg	80		95 897.70 [b]	←→	8.281 775 555 833
Th	90		125 253.40 [b]	←→	8.283 267 729 872
Fm	100		160 804.00 [b]	←→	8.286 011 987 216
Ds	110		204 400.00 [b]	←→	8.291 558 770 012
Rg	111		211 181.96 [c]	←	8.278 691 910 036 [d]
Cn	112		216 395.64 [c]	←	8.278 691 910 036 [d]
Fl	114		227 257.00 [c]	←	8.278 691 910 036 [d]
Lv	116		238 755.14 [c]	←	8.278 691 910 036 [d]
Og	118		250 947.50 [c]	←	8.278 691 910 036 [d]
xx [e]	119		257 386.97 [c]	←	8.278 691 910 036 [d]
xx [e]	120		264 022.11 [c]	←	8.278 691 910 036 [d]
xx [e]	122		278 037.10 [c]	←	8.278 691 910 036 [d]
xx [e]	126		309 790.06 [c]	←	8.278 691 910 036 [d]
xx [e]	130		348 967.80 [c]	←	8.278 691 910 036 [d]
xx [e]	132		373 260.57 [c]	←	8.278 691 910 036 [d]
xx [e]	134		403 395.73 [c]	←	8.278 691 910 036 [d]
xx [e]	136		447 172.13 [c]	←	8.278 691 910 036 [d]
xx [e]	137		494 269.44 [c]	←	8.278 691 910 036 [d]

*NIST: National Institute of Standards and Technology.

[a]Neutron, according to the assumption herein, it is treated as hydrogen atom in the discrete state $n^{-1} = 126$, according to Eq. (68), with $z = Z = 1$. https://physics.nist.gov/PhysRefData/ASD/ionEnergy.html

[b]The data is from NIST Atomic Spectra Database Ionization Energies Form;

[c]No data are available by NIST (June 30, 2020); the amount of V_{em} obtained by using Eq. (82), which can also be calculated from equation (87).

[d]The structural constant of hydrogen is used here, Eq. (87); s_0=8.278 691 910 036.

[e]The element has not been revealed yet, but in accordance with here presented theory the highest atomic number can be $Z = 137$.

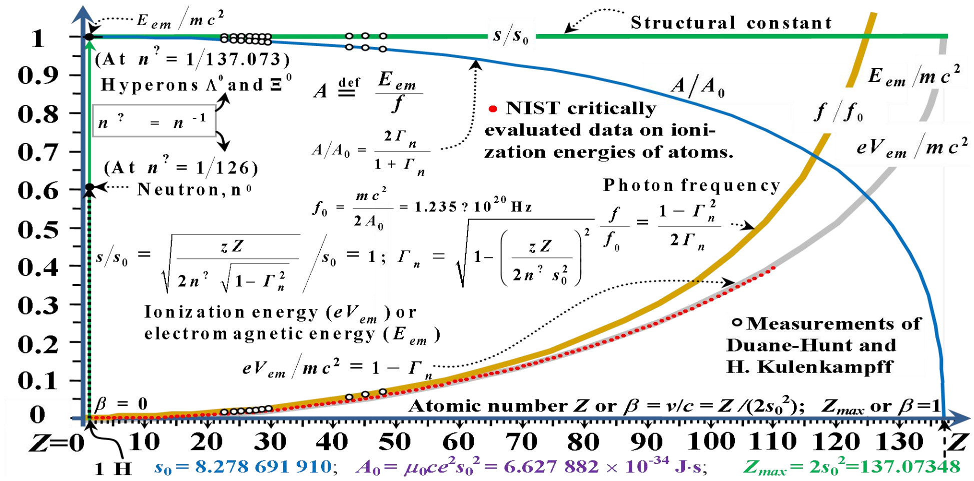

Figure 2. a) Electromagnetic energy of photon E_{em}, ionization energy of electron eV_{em}, photon frequency f, structural constant s, and LC oscillator action A, versus atomic number Z or electron speed $\beta = v/c$; $n = 1$; Measurements marked with "•" are from NIST, the remaining measurements, marked with "o", are from Duane-Hunt [14] and H. Kulenkampff [19].

7. Application of Structural Constant

The use of the structural constant has many applications. Here we will highlight three such applications in particular. One application is that the structural constant makes 9 existing constants redundant (Table 2). Another application of the structural constant is the transfer of continuous theory to discrete theory or Discrete Physics (Table 3). The third application of the structural constant, on which the introduction of the unit for the type of substance is based, 'boscovich', B=1/($2s_0^2$), [20].

The value of structural constant of atoms s_0 is the same for all atoms (Table 1). This is a Fundamental Physical Constant, (perhaps even in the category "Universal Constants", next to *characteristic impedance of vacuum*, *electric constant*, *magnetic constant*, *Newtonian constant of gravitation*, *Planck constant*, or *speed of light in vacuum*). When we know s_0 then we can from Eqs. (67, 68) calculate $V_{em1(n)}$, $V_{em2(n)}$, and all other sizes (Figure 2).

Structural constant can also be calculated in the following ways. The simplest way is to use von Klitzing constant, *i.e.*, $R_{\mathrm{K}} = 25\,812.807\,4555\,\Omega$, CODATA2014 https://physics.nist.gov/cgi-bin/cuu/Value?rk, stimulated by the Eq. (77):

$$s_0 = \sqrt{\frac{R_{\mathrm{K}}}{\mu_0 c}} = 8.277\,560\,000\,946\,. \tag{88}$$

Furthermore, for determining s_0 it is possible to use Planck's constant $(h = 6.626\,070\,040 \times 10^{-34}\ \mathrm{J \cdot s})$:

$$s_0 = \sqrt{\frac{h}{\mu_0 c e^2}} = 8.277\,560\,001\,045\,. \tag{89}$$

It is also possible to use Josephson's constant $(K_{\mathrm{J}} = 483\ 597.8525 \times 10^9\ \mathrm{Hz \cdot V^{-1}})$:

$$s_0 = \sqrt{\frac{2}{\mu_0 c e K_{\mathrm{J}}}} = 8.277\,560\,000\,946\,. \tag{90}$$

Finally, that s_0 can also be calculated using Rydberg's constant $(R_\infty = 10\ 973\ 731.568\ 508\ \mathrm{m^{-1}})$

$$s_0 = \sqrt[6]{\frac{m}{8\mu_0 e^2 R_\infty}} = 8.277\,560\,001\,301\,. \tag{91}$$

Table 2. Six initial constants (s_0, c, μ_0, e, m, m_p) convert nine below displayed constants in redundant

Quantity	Symbol	Formula	Value	Unit	Difference [a]
Structural constant	s_0	s_0	8.278 691 910 036 [b]	1	unknown
Speed of light in vacuum	c	c	299 792 458	$m \cdot s^{-1}$	0.000
Magnetic constant	μ_0	μ_0	$1.256\,637\,061 \times 10^{-7}$	$kg \cdot m \cdot A^{-2} \cdot s^{-2}$	0.000
Elementary charge	e	e	$1.602\,176\,621 \times 10^{-19}$	$A \cdot s$	0.000
Electron mass	m	m	$9.109\,383\,560 \times 10^{-31}$	kg	0.000
Proton mass	m_p	m_p	$1.672\,621\,898 \times 10^{-27}$	kg	0.000
	Down:	*9 redundant constants*	*derived from six initial*		
1. Fine-structure constant	α	$1/\left(2s_0^2\right)$	$7.295\,357\,233 \times 10^{-3}$	1	-0.027 [c]
1a). Inverse fine-structure c.	α^{-1}	$2s_0^2$	$1.370\,734\,795 \times 10^{2}$	1	+0.027 [c]
2. von Klitzing constant	R_K	$\mu_0 c s_0^2$	$2.581\,986\,745 \times 10^{4}$	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$	+0.027 [c]
3. Planck's constant	h	$\mu_0 c e^2 s_0^2$	$6.627\,882\,313 \times 10^{-34}$	$m \cdot kg \cdot s^{-1}$	+0.027 [c]
3a). Conversion constant	K_0	$1/\left(2\mu_0 c\, e\, s_0^2\right)$	$1.208\,664\,053 \times 10^{14}$	$m^2 \cdot kg \cdot s^{-4} \cdot A^{-1}$	unknown
4. Ratio $e/h = 2K_0$	e/h	$1/\left(\mu_0 c\, e\, s_0^2\right)$	$2.417\,328\,106 \times 10^{14}$	$m^2 \cdot kg \cdot s^{-4} \cdot A^{-1}$	-0.027 [c]
5. Josephson constant, $4K_0$	K_J	$2/\left(\mu_0 c\, e\, s_0^2\right)$	$4.834\,656\,212 \times 10^{14}$	$m^2 \cdot kg \cdot s^{-4} \cdot A^{-1}$	-0.027 [c]
6. Rydberg constant	R_∞	$m/\left(8\mu_0\, e^2\, s_0^6\right)$	$1.096\,473\,231 \times 10^{7}$	m^{-1}	-0.082 [c]
7. Bohr radius	a_0	$\mu_0 e^2 s_0^4/(\pi m)$	$5.294\,667\,174 \times 10^{-11}$	m	+0.055[c]
8. Bohr magneton	μ_B	$\mu_0 c e^3 s_0^2/(4\pi m)$	$9.276\,546\,489 \times 10^{-24}$	$A \cdot m^2$	+0.027 [c]
9. Nuclear magneton	μ_N	$\mu_0 c e^3 s_0^2/\left(4\pi m_p\right)$	$5.052\,165\,117 \times 10^{-27}$	$A \cdot m^2$	+0.027 [c]

[a]It is the difference with "2014 CODATA recommended values" in percent. [b]These calculation is based on the values provided by NIST, Eq. (87), $V_{em1(1)}$ = 13.598 434 49 V, https://www.nist.gov/pml/atomic-spectra-database. [c]This difference disappears completely if Planck's constant instead of $h = 6.626\,070\,040 \times 10^{-34}$ J·s is equal to $A_0 = 6.627\,882\,313\,1934 \times 10^{-34}$ J·s, *i.e.*, when it is increased by 0.027%.

8. Neutron as a hydrogen atom in discrete state $n^{-1} = 126$

If, for any reason, an electron falls below the first orbit $n^{\pm 1} = 1$, then the atom in that state can still exist. Suppose, therefore, that a neutron is in fact a hydrogen atom in one of the states n^{-1}. We will now determine which number n, below the level $n^{\pm 1} = 1$, belongs to that state of hydrogen atom or neutron. According to NIST, the mass of the proton is $m_P = 1.67262192369 \times 10^{-27}\,\text{kg}$, the mass of the neutron is $m_{n^0} = 1.67492749804 \times 10^{-27}\,\text{kg}$ and the mass of the electron is $m = 9.1093837015 \times 10^{-31}\,\text{kg}$. The mass of hydrogen is, Eq. (69), $m_H = m_P + m/\sqrt{1-\beta_H^2} = m_P + m/\Gamma_H = 1.67353295896 \times 10^{-27}\,\text{kg}$. The difference between the mass of neutrons and the mass of hydrogen, $\Delta m_H = m_{n^0} - m_H = 1.39453907917 \times 10^{-30}\,\text{kg} = (m_P + m/\sqrt{1-\beta_{n^0}^2}) - (m_P + m/\sqrt{1-\beta_H^2}) = m/\sqrt{1-\beta_{n^0}^2} - m/\sqrt{1-\beta_H^2} = m/\Gamma_{n^0} - m/\Gamma_H$, should then be attributed to the increase in the mass of electrons in the observed hydrogen atom as neutrons. It follows from here $\Gamma_{n^0} = m\,\Gamma_H/(m + \Delta m_H\,\Gamma_H)$. According to Eq. (69), with $z = Z = n^{\pm 1} = 1$, is $\Gamma_H = 0.999973389$. Therefore, the solution of the previous equation, which is now, with the help of Eq. (69), written in extended form, [see Eq. (92)].

Table 3. Link of Continuous (Classical) and Discrete Physics

Quantity	Symbol	Eq.	Continuously	Eq.	Discretely
Structural constant	s_0	(77)	$\sqrt{zZ\pi\sqrt{L/C}\,/(\mu_0 c)}$	(87)	$\sqrt{zZ/(2n^{\pm1}\sqrt{1-\Gamma_n^2}\,)}$
Particle velocity	v	(8)÷ (9)	$\sqrt{-2qV_{em}\left[1+qV_{em}/(2mc^2)\right]/m}$	(62)	$c\,zZ/\left(2n^{\pm1}s_0^2\right)$
Ratio v/c	β	(1)÷ (2)	v/c	(62)	$zZ/\left(2n^{\pm1}s_0^2\right)$
Abbreviation	Γ_n	(69)	$\sqrt{1-\beta^2}$	(69)	$\sqrt{1-\left[zZ/\left(2n^{\pm1}S_0^2\right)\right]^2}$
Ratio $(v/c)^2$	β^2	(8)÷ (9)	$(v/c)^2$	(69)	$1-\Gamma_n^2$
Relativistic moment	p	(2)	$mc\beta/\sqrt{1-\beta^2}$	(50)	$m\,c\left(1\text{-}\Gamma_n^2\right)/\Gamma_n$
Orbit radius	r	(4)	$-\,qQ\sqrt{1\text{-}\beta^2}/\left(4\pi\varepsilon_0\beta^2mc^2\right)$	(4, 69)	$zZ\mu_0e^2\Gamma_n/\left[4\pi m(1\text{-}\Gamma_n^2)\right]$
Orbit radius	r	(13)	$\mu_0c^2Q\left[1+qV_{em}/\left(mc^2\right)\right]/\left\{8\pi V_{em}\left[1+qV_{em}/\left(2mc^2\right)\right]\right\}$	(70)	$(n^{\pm1})^2\mu_0e^2s_0^4\Gamma_n/\left(\pi mzZ\right)$
Kinetic energy	K	(5)	$mc^2/\sqrt{1-\beta^2}-mc^2$	(80)	$mc^2\left(1/\Gamma_n\text{-}1\right)$
Potential energy	U	(6)	$-m\,c^2\beta^2/\sqrt{1-\beta^2}$	(79)	$mc^2\left(\Gamma_n\text{-}1/\Gamma_n\right)$
Mechanical energy	W	(7)	$-m\,c^2\left(1-\sqrt{1-\beta^2}\right)$	(81)	$mc^2(\Gamma_n-1)$
Electromag. energy	E_{em}	(8)	$m\,c^2\left(1-\sqrt{1-\beta^2}\right)=-\,qV_{em}$	(82)	$mc^2(1-\Gamma_n)$
Potential difference	V_{em}	(67)	$-m\,c^2\left(1-\sqrt{1-\beta^2}\right)/\,q$	(67, 68)	$mc^2\left(1\pm\Gamma_n\right)/(ze)$
Coulomb pot., U/q	V_U	(70÷71)	$Q/(4\pi\varepsilon_0\,r)=U/q$	(71)	$mc^2\left(1/\Gamma_n\text{-}\Gamma_n\right)/(ze)$
Capacitance	C	(20)	$4\pi\varepsilon_0r$	(85)	$(2n^{\pm1})^2e^2s_0^4\Gamma_n/\left(mc^2zZ\right)$
Inductance	L	(16)	$1/(4\pi^2f^2C)$	(86)	$zZ\mu_0^2e^2\Gamma_n/\left[(2n^{\pm1}\pi)^2m(1\text{-}\Gamma_n^2)^2\right]$
Oscillator frequency	f	(42)	$1/\left(2\pi\sqrt{LC}\right)=-qV_{em}/A$ [a]	(43, 69)	$mc^2(1\text{-}\Gamma_n^2)/(2A_0\,\Gamma_n)$
Action constant	A_0	(37, 77)	$zZ\pi\sqrt{L/C}\,e^2$	(37)	$\mu_0\,c\,e^2s_0^2$
LC oscillator action	A	(8, 42)	$E_{em}/f=2\pi mc^2\left(1\text{-}\sqrt{1\text{-}\beta^2}\right)\sqrt{LC}$	(40)	$A_0\left[2\Gamma_n/\left(1+\Gamma_n\right)\right]$
Planck's h is variable[b]	h	(36)	E_{em}/f	(36, 48)	$A_0\left[2\Gamma_n/\left(1+\Gamma_n\right)\right]$

[a]It is simultaneously Duane-Hunt's law in expanded form.
[b]Definition of h: The Planck constant, h, is equal to the energy E_{em} of a quantum of electromagnetic radiation divided by its frequency f, https://en.wikipedia.org/wiki/Planck_constant, see $A/A_0 \Rightarrow h/A_0$ in Figure 2, from which it can be seen that h is approximately constant up to the velocities of the body below 10% of the speed of light, and with increasing speed it decreases all the way to zero.

$$\sqrt{1-\left(\frac{1}{n_{\mathrm{n}^0}^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}=\frac{\sqrt{1-\left(\frac{1}{n_{\mathrm{H}}^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}}{1+\frac{\Delta m_{\mathrm{H}}}{m}\sqrt{1-\left(\frac{1}{n_{\mathrm{H}}^{\pm1}}\frac{zZ}{2s_0^2}\right)^2}} \tag{92}$$

is $n_{\mathrm{n}^0}^{\pm1}=n_{\mathrm{n}^0}^{-1}=125.92000300221$. According to Eqs. (59, 60), here must be an integer, so that the real solution is $n_{\mathrm{n}^0}^{-1}=126$, where the error is 0.064%. The ionization potential of neutrons is calculated from equation (68) and this ionization potential (z=Z=1, $n^{\pm1}$=1/126) is $V_{em_{\mathrm{n}^0}}=712\,207.8053$ V.

9. Conclusion

Maxwell's theory of electromagnetism and the relativity theory give here good results in describing most phenomena in the atom, such as the radiation of energy, discretization of the state in the atom, determination of stationary orbits, determining and calculating the structural constant of the atom. These theories enable for the transfer of continuous theory into the discrete theory of atoms. The discrete theory, apart from the description of the state in the electron shell, hence, in the higher orbits of the atoms, allows entry into the orbits that are theoretically present and under the first orbit of the atom, what lead towards the nuclei of atoms. The theory presented here explains that in atoms, in addition to discrete states $n^{+1} = 1, 2, 3$, discrete states $n^{-1} = 1, 2, 3$, are also present. Therefore, it is possible that in the discrete state $n^{-1} = 126$ the hydrogen atom acquires the properties of a neutron. The resulting neutron then, with another proton, builds a nucleus of deuterium, tritium, and all others nucleus. Protons and electrons are then attracted to the nuclei, which overcome the mutual repulsive force of the protons. To achieve all this, the presence of an electromagnetic oscillator within the atom is assumed. This oscillator is described using the Lecher line. Discretization is introduced through the integer ratio of the natural frequency of electromagnetic oscillations in the atom and the frequency of rotation of the electron around the nucleus of the atom. This integer ratio allows stable states of the atom. The experimental results are in agreement with the presented theory. Introduced structural constant s_0 help to make redundant 9 other physical constants, it is in detail explained and this constant amounts 8.278691910. This structural constant allows other research to continue; one of them is the unit for type of substance. The exposition in this article is based on one-electron atoms. Multiple-electron atoms, on the foundations set up here, should be separate research. It is shown that Planck's h is not constant, and that it can be considered constant only in cases when the speed of the observed body is lower than about 10% of the speed of light. At body speeds greater than 10% of the speed of light, Planck's h gradually decreases even to zero. This article is written in a logical, physical, and formally clear sequence, so that all concepts are perfectly clear as much as they are clear in classical physics.

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