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The Structural Constant s_0 of All Atoms as a Universal Physical Constant

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Abstract

A universal physical constant (or fundamental constant) is an empirical physical quantity that remains unchanged throughout the universe and across time. All of these properties are satisfied by the structural constant of all atoms s_0, shown in the article [1], and fine-structure constant $\alpha = e^2/(2\varepsilon_0 hc)$, which was introduced into physics by Arnold Sommerfeld in 1915, and therefore we can claim that that constants are universal physical constants which is also called a natural constants like the speed of light c, Newton constant of gravitation G, vacuum magnetic permeability μ_0, vacuum electric permittivity ε_0 or others, like cosmological constant Λ, elementary charge e, electron mass m_e, proton mass m_p, neutron mass m_n or Avogadro constant N_A and so on. I note that Planck's h is not among the above-mentioned universal constants. The reason for this is that according to my earlier research Planck's h is a complex physical quantity consisting of the aforementioned universal constants and structural constant s_0: $h = \mu_0 ce^2 s_0^2$, [2]. If the fine-structure constant α is determined precisely in a different way, as done in the article [3], then expression α is used to determine Planck's h and finally to calculate the structural constant s_0. We will use this fact to write this article. With very precise data for the fine-structure constant α, this is the most accurate calculation for s_0.

Keywords

Fine-Structure Constant, Structural Constant of All Atoms, Mendeleev's Periodic Table, Unit of Substance Type "Boscovich", Universal Physical Constant

1. Introduction

The structure constant s_0 of all atoms refers to the quantity obtained when all atoms in the Mendeleev's periodic table are ionized, when electrons are ejected from

each atom, down to the last electron, until the atom is ionized to the very nucleus of each atom.

I note that the structure constant s_0 was independently measured when measuring the ionization energy of all atoms [1]:

$$s_0 = \frac{\sqrt{zZ}}{\sqrt{2n^{\pm 1}\sqrt{1-\left[1-\frac{eV_{\mathrm{em(n)}}}{mc^2}\right]^2}}}.$$

Let us now recall the meaning of quantities in this equation. Z is the atomic number in Mendeleev's periodic table, z is the number of electrons in one orbital of the atom, $n^{\pm 1}$, is the ordinal number of an orbital (shall) in an atom. This expression, in addition to the usual paths $n = n^{+1} = 1,2,3,4,\cdots$, also predicts paths $n = n^{-1} = 1,2,3,4,\cdots$, which opens up the possibility of electron paths in the atom below the first orbit, so for ex ample a neutron can be considered a hydrogen atom with path $n = n^{-1} = 126$, whereby the mass of the electron in neutron due its speed and relativistic effects increases so much that the neutron become 0.14% heavier than the proton [2], m is the rest mass of one electron, c is the speed of light in vacuum, e is the charge of one electron and $V_{\mathrm{em(n)}}$ is the ionization potential of a single atom.

From the previous equation for s_0, two equations for V_{em} are obtained:

$$V_{\mathrm{em(1)}} = \frac{mc^2}{ze}\left[1-\sqrt{1-\left(\frac{1}{n^{\pm 1}}\frac{zZ}{2s_0^2}\right)^2}\right],$$

$$V_{\mathrm{em(2)}} = \frac{mc^2}{ze}\left[1+\sqrt{1-\left(\frac{1}{n^{\pm 1}}\frac{zZ}{2s_0^2}\right)^2}\right].$$

The solution $V_{\mathrm{em(1)}}$ is for the lower (ionization) voltages (namely, we will see later after we determinate s_0, for $q = -e$, $z = 1$, $n^{\pm 1} = 1$) when Z is going from 0 to 137.035999166(15), than ionization voltage $V_{\mathrm{em(1)}}$ is going from 0 V to 510 999 V, and the solution $V_{\mathrm{em(2)}}$ ($q = -e$, $z = 1$, $Z = 1/n^{\pm 1}$) when Z is going from 0 to 137.035999166(15) (ionization) voltage $V_{\mathrm{em(2)}}$ goes in opposite direction from 1 020 130 V to 510 999 V.

The value of structural constant s_0 is the same for all atoms (see **Table 1**).

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

Chemical symbol	Atom number Z	Ionization voltage [V]	Structural constant s_0	Remark
n^0, H	1	712207.805, 13.59843449*	8.278691910036	In $V_{\mathrm{em(2)}}$ $n^{-1} = 126$
He	2	54.4177650*	8.277860595602	
Li	3	122.4543581*	8.277755226469	
Be	4	217.7185843*	8.277739553105	

Continued

B	5	340.226020*	8.277739896484	
C	6	489.993194*	8.277757231963	
N	7	667.046116*	8.277771755296	
O	8	871.409880*	8.277791688375	
F	9	1103.11747*	8.277812276144	
Ne	10	1362.19915*	8.277842618038	
Ca	20	5469.8615*	8.278203152589	
Zn	30	12388.929*	8.278637976575	
Zr	40	22236.677*	8.279106265650	
Sn	50	35192.39*	8.279610860584	
Nd	60	51515.58*	8.280166600276	
Yb	70	71574.80*	8.280846679237	
Hg	80	95897.70*	8.281775555833	
Th	90	125253.40*	8.283267729872	
Fm	100	160804.00*	8.286011987216	
Ds	110	204394.00*	8.291558770012	Latest data at NIST

NIST: National Institute of Standard and Technology.
https://en.wikipedia.org/wiki/National_Institute_of_Standards_and_Technology
*https://physics.nist.gov/PhysRefData/ASD/ionEnergy.html

As we can see, all s_0 values for all atoms are concentrated around the value 8.278 - 8.291. For precise determination, more accurate measurement is required. For this purpose, we will use another most accurate measurement.

The most accurate value of the inverse fine-structure constant, more accurate than previous results obtained based on the ionization energies of atoms, [1], is given in the article [3] and it is by Arnold Sommerfeld:

$$\alpha^{-1} = 2\varepsilon_0 hc/e^2 = 137.035999166(15)[0.11\ \text{ppb}]. \quad (1)$$

This was obtained by measuring the magnetic moment of the electron, which is the most accurate way to determine the fine-structure constant α. Therefore, this can be a guide for determining the structure constant s_0, and we will use it in the following.

We assume that Planck's h in Equation (1) is not predefined. Therefore, Planck's h from Equation (1) can be expressed as:

$$h = \alpha^{-1}e^2/(2\varepsilon_0 c) = \alpha^{-1}e^2\mu_0 c/2, \quad (2)$$

taking into account that it is worth:

$$\mu_0\varepsilon_0 c^2 = 1. \quad (3)$$

Planck's h is, according to article [2], based on the Lecher line model of the atom [2], equal to:

$$h = \mu_0 ce^2 s_0^2 . \tag{4}$$

Here is the explanation! The characteristics of an oscillatory circuit obtained from a Lecher line depend only on the parameters of inductance L and capacitance C of that circuit, and not on variables in that circuit, such as charges, currents, or voltages. Thus, it was shown that the electromagnetic energy E_{em} of this oscillator is proportional to its own frequency $f = 1/\left(2\pi\sqrt{LC}\right)$, and a constant h, $E_{\text{em}} = hf$, and this constant h itself is $h = \mu_0 ce^2 s_0^2$. This represents the well-known Planck's law for the energy of an electromagnetic wave, and here it is the energy of an electromagnetic oscillator created from a Lecher line.

Using Equation (1), and equating Equations (2) and (4), the structural constant s_0 is obtained:

$$s_0 = \sqrt{\frac{1}{2}} = 8.27756 . \tag{5}$$

Using Equation (5), and according to article [2], the maximum number of different type of atoms in Mendeleev's table, not counting isotopes, is:

$$1/B = 2s_0^2 = 137.035999166 . \tag{6}$$

The explanation for the stated amount comes from determining the speed that an electron can reach in the first shell of an atom ($n^{\pm 1} = 1$) in relation to the speed of light:

$$\beta_{\max} = \frac{v_{\max}}{c} = \frac{1}{n^{\pm 1}} \frac{zZ_{\max}}{2s_0^2} = 1 .$$

From here for $z = 1$, $n^{\pm 1} = 1$ it follows that $Z_{\max} = 2s_0^2$, that is Equation (6).

From Equation (6) it follows that the distance between two adjacent types of atoms, and I suggest that this measure be called a unit of measurement for a type of substance "boscovich", B, [4] is equal to:

$$B = 1/\left(2s_0^2\right) = 7.297352568 \times 10^{-3} . \tag{7}$$

Equation (7) simultaneously represents the fine-structure constant α according to NIST in 2022 CODATA.

From Equations (4) and (5) comes Planck's h:

$$h = \mu_0 ce^2 s_0^2 = 6.626070159 \times 10^{-34}\ \text{J} \cdot \text{Hz}^{-1} . \tag{8}$$

This value in Equation (8) exactly matches the value of Planck's h obtained by NIST in 2022, CODATA. In the same time, it can be seen from **Table 2** that all other results are precisely aligned with NIST in 2022 CODATA, *i.e.*, without difference, using the results from article [3] and the results from the two remaining articles [1] and [2].

Such good agreement of the results with CODATA values using the new constant s_0 would not be possible without a new fundamental constant s_0, which is independent and precisely measurable. Namely if s_0 were not a universal physical constant, at least one of the 9 physical quantities in **Table 2** would not match the values in CODATA 2022.

Table 2. Eight (8) initial constants (s_0, B, $1/B$, c, μ_0, e, m, m_p) convert (9) nine constants in interchangeable.

Quantity	Symbol	Formula	Value	Unit	Difference[a]
Structural constant of all atoms	s_0	s_0 Equation (5)	8.27756[b]	1	unknown
Unit of substance type = boscovich	B	$1/(2s_0^2)$ Equation (7)	$7.297352568 \times 10^{-3}$	1	0.0000
Max. number of diff. type of atoms	$1/B$	$2s_0^2$ Equation (6)	137.035999166	1	0.0000
Speed of light in vacuum	c	$\varepsilon_0\mu_0c^2=1$	299792458	$m{\cdot}s^{-1}$	0.0000
Vacuum magnetic permeability	μ_0	μ_0	$1.256637061 \times 10^{-6}$	$N{\cdot}A^{-2}$	0.0000
Elementary charge	e	e	$1.602176634 \times 10^{-19}$	C	0.0000
Electron mass	m	m	$9.1093837139 \times 10^{-31}$	kg	0.0000
Proton mass	m_p	m_p	$1.6726219259 \times 10^{-27}$	kg	0.0000
Down: 9 *interchangeable constants*					
1. Fine-structure constant: $e^2/(2\varepsilon_0hc)$	α	$e^2/(2\varepsilon_0hc)$ Equation1	$7.2973525643 \times 10^{-3}$	1	0.0000
1. a) Inverse-fine structure constant	α^{-1}	$2\varepsilon_0hc/e^2$ Equation1	$1.370035999 \times 10^{2}$	1	0.0000
2. von Klitzing constant	R_K	$\mu_0cs_0^2$	$2.581280744 \times 10^{4}$	Ω	0.0000
3. Planck constant	h	$\mu_0ce^2s_0^2$	$6.626070158 \times 10^{-34}$	$J{\cdot}Hz^{-1}$	0.0000
3. a) Conversion constant, K_0	K_0	$1/(2\mu_0ces_0^2)$	$1.208994631 \times 10^{14}$	$Hz{\cdot}V^{-1}$	unknown
4. Ratio $e/h=2K_0$	e/h	$1/(\mu_0ces_0^2)$	$2.41798926 \times 10^{14}$	$Hz{\cdot}V^{-1}$	0.0000
5. Josephson constant $=4K_0$	K_J	$2/(\mu_0ces_0^2)$	$4.835978524 \times 10^{14}$	$Hz{\cdot}V^{-1}$	0.0000
6. Rydberg constant	R_∞	$m/(8\mu_0e^2s_0^6)$	$1.0973731568 \times 10^{7}$	m^{-1}	0.0000
7. Bohr radius	a_0	$\mu_0e^2s_0^4/(\pi m)$	$5.291772116 \times 10^{-11}$	m	0.0000
8. Bohr magneton	μ_B	$\mu_0ce^3s_0^2/(4\pi m)$	$9.274010015 \times 10^{-24}$	$J{\cdot}T^{-1}$	0.0000
9. Nuclear magneton	μ_N	$\mu_0ce^3s_0^2/(4\pi m_p)$	$5.050783626 \times 10^{-27}$	$J{\cdot}T^{-1}$	0.0000

[a]It is the difference with "2022 CODATA recommended values" in percent. https://physics.nist.gov/constants. [b]This calculation is based on the values provided by Equation (1), Equation (2) and Equation (4). Structural constant s_0 has not yet been included in the physical quantities at NIST. The exact results from this article should change that and the structural constant of all atoms s_0 should be included in the universal physical constants.

2. Methods

This article uses a theoretical and experimental approach. First, the method of Measurement of the Electron Magnetic Moment in [3] was used. From there, a very precise inverse value of the fine-structure constant was obtained in Equation (1). From Equation (1) express the unknown Planck's $h=\alpha^{-1}e^2\mu_0c/2$ in Equation (2). Since according to article in [2] Planck's h is equal to $h=\mu_0ce^2s_0^2$ then from these last two equations it follows $s_0=\sqrt{\frac{1}{2}}=8.27756$, that is, Equation (5).

Planck's h thus derived from the Lecher line as an oscillator is consistent with QED, as can be seen from the article [2]. Thus, we accurately calculated the structure constant of all atoms s_0 in the simplest way. Table 2 shows the significance and value of this calculation of the structural constant of all atoms s_0, because through this constant all the values of all 9 interchangeable constants in that Table

2 are obtained exactly in accordance with NIST 2022 CODATA. This fulfills the prerequisites for declaring the structural constant of all atoms s_0 as a universal physical constant.

Maxwell theory with Theory of relativity give good result in describing most phenomena in the atom, such as the radiation of electromagnetic energy, discretization of states in the atom, the determination of stationary orbits, the determination and calculation of the structural constant of the atom s_0.

3. Results

The theory presented here explains that in atoms, in addition to the discrete states $n^{+1} = 1, 2, 3, 4$ discrete states $n^{-1} = 1, 2, 3, 4$, are also present. Therefore, for example, it is possible that in the discrete states $n^{-1} = 126$ a hydrogen atom acquires the properties of a neutron. To achieve this, the existence of an electromagnetic oscillator inside the atom is assumed. This oscillator is described using the Lecher transmission line. The Lecher line does not actually exist within an atom however, a mathematical model of that line is used, just a mathematical is used in space exploration without the actual presence of planets in that model.

In the paper [2] it was shown that an oscillator derived from the Lecher line corresponds to an atom as an oscillator according to QED (Quantum electrodynamics). Thus, the emitted or absorbed electromagnetic energy of the atom is proportional to the natural frequency f_n of that oscillator and the quantity $h = \mu_0 c e^2 s_0^2$, which by definition is Planck's constant. Provided that s_0 is constant, which the measurements in Table 1 show, this is a different way to derive Planck's constant within the framework of QED. In this case, the natural frequency of the oscillator f_n is equal to [2]:

$$f_n = \frac{mcz^2Z^2}{8e^2\mu_0\left(n^{\pm 1}\right)^2 s_0^6\sqrt{1-\left(\frac{1}{n^{\pm 1}}\frac{zZ}{2s_0^2}\right)^2}}.$$

The maximum number $Z = Z_{\max}$ in periodic table, not counting isotopes, is determined by the velocity $v_{\max}$, which can be reached by an electron ($z = 1$) in its first shell ($n^{\pm 1} = 1$) relative to the speed of light, *i.e.* when $\beta_{\max} = \frac{v_{\max}}{c} = \frac{1}{n^{\pm 1}}\frac{zZ_{\max}}{2s_0^2} = 1$. For $z = 1$ and $n = 1$ $Z_{\max} = 2s_0^2 = 137.035999166$. Since this number is related to the maximum speed of electrons in an atom, this number does not necessarily have to be a whole number.

4. Conclusions

First, the method of Measurement of the Electron Magnetic Moment in [3] was used. From there, a very precise inverse value of the fine-structure constant was obtained in Equation (1). From Equation (1) express the unknown Planck's $h = \alpha^{-1}e^2\mu_0 c/2$ in Equation (2). Since according to article in [2] Planck's h is equal to $h = \mu_0 c e^2 s_0^2$ then from these last two equations it follows $s_0 = \sqrt{\frac{1}{2}} = 8.27756$,

that is, Equation (5). Thus, we accurately calculated the structure constant of all atoms s_0 in the simplest way. Table 2 shows the significance and value of this calculation of the structural constant of all atoms s_0, because through this constant all the values of all 9 interchangeable constants in that Table 2 are obtained exactly in accordance with NIST 2022 CODATA. This fulfills the prerequisites for declaring the structural constant of all atoms s_0 as a universal physical constant.

It is crucial for this article that it directly adopts the results for the fine-structure constant $\alpha = e^2/(2\varepsilon_0 hc)$ obtained from the article [3]. It is important to note that in this expression Planck's h is considered a variable, $h = \mu_0 ce^2 s_0^2$, the value of which has yet to be determined. By equating Planck's h from the previous two expressions, it is possible to calculate the structural constant s_0 of all atoms: $s_0 = \sqrt{\frac{1}{2}} = 8.27756$. As can be seen from Table 2, this has achieved an important goal. Namely, now with the help of eight initial constants (s_0, B, $1/B$, c, μ_0, e, m, m_p), nine other constants (α, R_K, h, e/h, K_J, R_∞, a_0, μ_B, μ_N; https://physics.nist.gov/constants) are converted into interchangeable. It is important to note that all of these 9 obtained quantities have values equal to those of NIST in 2022 CODATA. This means that the structural constant of all atoms derived here, s_0 = 8.7756, can be taken as a new universal physical constant, with which constant is all this simple and easy to do. The method of calculating all 9 physical quantities using that structural constant s_0 is listed in Table 2, see the formulas in that table.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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