Analytical method high-precision determination of values of fundamental physical constants

Within the framework one created of by the author of this article Pi-Theory fundamental physical constants is expounded principally new analytical method high-precision determination of values of fundamental physical constants. Presents the formulae and the results of analytical calculations. Presents selected data CODATA 2010 and the results of their comparison with the calculations. Provides the analysis of the problems of theoretical determination of the numerical values of the fine structure constant.

In the journal UFN **183** 935-962 (2013) published the article by the Chairman of russian of group CODATA of S.G. Karshenboim "Progress in the accuracy of the fundamental physical constants: 2010 CODATA recommended values", which provides an overview of the current state of Affairs with the definition of the values of the fundamental physical constants (hereinafter – the FPC).

Judging from the content of the review, the author of this is article concludes that there are virtually no analytical methods of theoretical determination of the values of the FPC. Further outlined analytical method high-precision determination of values of FPC.

Required clarification: if in the text of article designation parameter has a lower index of "π", that is, first of all, parameter Pi-Theory of the fundamental physical constants (hereinafter - Pi-Theory), and secondly, that this parameter has the theoretical value that can be used instead of the true value of parameter.

Fine structure constant α and anomaly magnetic moment electron a_e

We shall result the citation from mentioned article:

"Most accurate method of determining the fine structure constant remains the study of the anomalous magnetic moment of the electron, the measurements of which refers to quantum optics in the traps for of single particles, as theory - to quantum electrodynamics".

In other words, for the theoretical determination of the fine structure constant $\alpha(a_e)$ method of perturbation theory of quantum electrodynamics as an input parameter is used the experimental value of the anomalies of the magnetic moment of the electron a_e.

The main disadvantages of this method are:

1. Parameter $\alpha(a_e)$ is determined with an accuracy not of higher of precision experimental value a_e. This is fully true for the of dependence of the species $a_e(\alpha)$.

2. In Pi-Theory α and a_e are *not time-dependent* fundamental constant of nature and, therefore, have the unique values, regardless of any physical measurements. It is obviously their difference $\Delta = \alpha - a_e$ also there is a unique constant. Not knowing the true meaning Δ, we can't rightly discern α, because α – the constant of nature, and absolutely *not depend* from a_e. Therefore, when used the any of the methods of determination α, not knowing the true meaning Δ is absolutely impossible to determine the true value α, even if the true value a_e somehow become known to us.

For explanations of the foregoing, we consider two problems arising from the theoretical definition $\alpha(a_e)$.

We write the equation:

$$z = x + y. \qquad (1)$$

Denote $x = a_e$, $z = \alpha$, then (1) can be written as

$$\alpha = a_e + y. \qquad (2)$$

From (2) that

$$y = \alpha - a_e \qquad (3)$$

and then (2) can be written as

$$\alpha = a_e + (\alpha - a_e). \qquad (4)$$

For option $\alpha = f(a_e)$, (4) can be written as

$$\alpha(a_e) = a_e + (\alpha - a_e) \qquad (5)$$

or in the form of

$$\alpha = a_{\text{e}} + [\alpha(a_{\text{e}}) - a_{\text{e}}]. \tag{6}$$

<u>The first problem</u> is that of (5) and (6) it follows that for *any* numeric values of the argument a_{e} equality (5) and (6) are satisfied. It is unclear how can be ascertained that is the found the number $\alpha(a_{\text{e}})$ matches the true largest α.

Given that, $\Delta = \alpha - a_{\text{e}}$, (5) can be written as

$$\alpha(a_{\text{e}}) = a_{\text{e}} + \Delta, \tag{7}$$

then

$$\Delta = \alpha(a_{\text{e}}) - a_{\text{e}}. \tag{8}$$

<u>The second problem</u> is that from (8) that, without knowing the true meaning Δ, can get, by finding the coefficients of the series $\alpha(a_{\text{e}})$, at known value a_{e}, *any* values α.

Compton wavelength λ_{C} and Planck constant h

Let we know true value α. In this case, the accuracy with which you can define λ_{C}?

We write to the well-known formula:

$$\alpha^2 = R_\infty \frac{2h}{m_{\text{e}} c}. \tag{9}$$

Given that, $\lambda_{\text{C}} = h / m_{\text{e}} c$, (9) can be written as

$$\lambda_{\text{C}} = \alpha^2 / 2 \cdot R_\infty. \tag{10}$$

From (10) λ_{C} that is defined with a precision of Rydberg's constant R_∞, because are error α is equal to zero.

We write (9) relating to the h:

$$h = \frac{\alpha^2 \cdot m_{\text{e}} c}{2 \cdot R_\infty}. \tag{11}$$

Given (10), (11) can be written as

$$h = m_{\text{e}} \cdot (\lambda_{\text{C}} \cdot c). \tag{12}$$

From (12) it follows that it is impossible to determine h, not knowing the value of the mass electron m_{e}.

Options for the identification of values α and a_{e}

In view of what is $\Delta_{\pi a}$ and $\kappa_{\pi e}$ – is independent from each other constants, then by condition

$$a_{\pi \text{e}} = \kappa_{\pi e} - \Delta_{\pi a} \tag{13}$$

there are the following options:

1. From the condition (13), $\kappa_{\pi e}$ the can be written as an unknown κ_x, if are known $\Delta_{\pi a}$ and a_{e}:

$$\kappa_x = a_{\text{e}} + \Delta_{\pi a}. \tag{14}$$

Taking into account (14), the constant of thin structure α_x can be written as:

$$\alpha_x = 2\pi \cdot \kappa_x. \tag{15}$$

2. From the condition (13), $a_{\pi \text{e}}$ the can be written as an unknown $a_{\text{e}x}$, if are known $\Delta_{\pi a}$ and κ_e:

$$a_{\text{e}x} = \kappa_e - \Delta_{\pi a}, \text{ где } \kappa_e = \alpha / 2\pi. \tag{16}$$

Note that, all mentioned in the text the are dimensional FPC are calculated with the accuracy of Rydberg's constant.

Theoretical determination of the values of FPC

Table 1. Presents the results of analytical calculations of values of the FPC in Pi-Theory.

Quantity	Symbol	Value (Pi-Pheory)
		Elementary constants
*electromagnetic constant asymmetry	$\Delta_{\pi a}$	1.757 552 613 321 940 865 158 064 461 x 10^{-6}
*Scalar parameter structure of space - time	$f_{\pi s}$	1.161 712 977 019 596 928 970 254 552 x 10^{-3}
*Scalar parameter of elementary charge	$\kappa_{\pi e}$	1.161 409 733 400 893 939 488 207 987 x 10^{-3}
		Compound constants
fine structure constant	α_{π}	7,297 352 572 519 857 423 545 858 624 x 10^{-3}
electron magnetic moment anomaly	$a_{\pi \mathrm{e}}$	1,159 652 180 787 571 998 623 049 923 x 10^{-3}
constant of scale invariance	ψ_{π}	1.669 642 831 928 813 892 580 472 149 x 10^{-23}
electron-proton mass ratio	$r_{\pi \mathrm{ep}}$	5,446 170 218 699 090 667 403 109 650 x 10^{-4}
electron-neutron mass ratio	$r_{\pi \mathrm{en}}$	5,438 673 446 906 118 561 918 007 850 x 10^{-4}
neutron-proton mass ratio	$r_{\pi \mathrm{np}}$	1,001 378 419 180 000 000 000 000 000
proton-neutron magnetic moment ratio	$r_{\pi\mu,\mathrm{pn}}$	-1,459 898 124 622 977 783 495 815 120

Note to table 1: the constants marked with * are the basic, i.e. independent from each other constants, and who, consequently, are the solutions of independent equations Pi-Theory. All other FPC of table 1 are not elementary, i.e. they are a combinations of elementary constants but also are the solutions the of equations of Pi-Theory.

Table 2. Presents the results of analytical calculations of values of the FPC. In the calculations we used: data of the table 1; the Rydberg's constant $R_{\infty} = 1{,}097\ 373\ 156\ 8539(55) \cdot 10^{5}\ \mathrm{sm}^{-1}$ (CODATA 2010); the speed of light $2{,}99792458 \cdot 10^{10}\ \ \mathrm{sm} \cdot s^{-1}$; surface density of the mass of the electron ρ_{Se}, the numerical value of the which in Pi-Theory is set to unity: $\rho_{\mathrm{Se}} = 1\ \mathrm{g} \cdot sm^{-2}$.

Quantity	Symbol	Formula (Pi-Theory)	Value (SGS)	Unit (SGS)
1	2	3	4	5
fine-structure constant	α_{π}	$\alpha_{\pi} = 2\pi \cdot \kappa_{\pi e}$	7.297 352 572 519 857 x 10^{-3}	
electron magnetic moment anomaly	$a_{\pi \mathrm{e}}$	$a_{\pi \mathrm{e}} = \kappa_{\pi e} - \Delta_{\pi a}$	1.159 652 180 787 572 x 10^{-3}	
Compton wavelength	$\lambda_{\pi \mathrm{C}}$	$\lambda_{\pi \mathrm{C}} = 2\pi^{2} \cdot \kappa_{\pi e}^{2} / \bar{R}_{\infty}$	2.426 310 240 7357 x 10^{-10}	sm
classical electron radius	$r_{\pi \mathrm{e}}$	$r_{\pi \mathrm{e}} = \kappa_{\pi e} \cdot \lambda_{\pi \mathrm{C}}$	2.817 940 329 8407 x 10^{-13}	sm
Bohr radius	$a_{\pi 0}$	$a_{\pi 0} = \lambda_{\pi C} / 2\pi \cdot \alpha_{\pi}$	0.529 177 211 1187 x 10^{-8}	sm
electron mass	$m_{\pi \mathrm{e}}$	$m_{\pi \mathrm{e}} = \pi^{2} \cdot f_{\pi s}^{3} \cdot \lambda_{\pi \mathrm{C}}^{2} \cdot \rho_{\mathrm{Se}}$	9.109 382 325 3402 x 10^{-28}	g
electron-proton mass ratio	$r_{\pi \mathrm{ep}}$	$r_{\pi \mathrm{ep}} = m_{\mathrm{e}} / m_{\mathrm{p}}$	5.446 170 218 699 091 x 10^{-4}	
proton mass	$m_{\pi \mathrm{p}}$	$m_{\pi \mathrm{p}} = m_{\pi \mathrm{e}} / r_{\pi \mathrm{ep}}$	1.672 621 669 8229 x 10^{-24}	g
proton Compton wavelength	$\lambda_{\pi \mathrm{C,p}}$	$\lambda_{\pi \mathrm{C,p}} = r_{\pi \mathrm{ep}} \cdot \lambda_{\pi \mathrm{C}}$	1.321 409 857 4420 x 10^{-13}	sm
electron-neutron mass ratio	$r_{\pi \mathrm{en}}$	$r_{\pi \mathrm{en}} = m_{\mathrm{e}} / m_{\mathrm{n}}$	5.438 673 446 906 119 x 10^{-4}	
neutron mass	$m_{\pi \mathrm{n}}$	$m_{\pi \mathrm{n}} = m_{\pi \mathrm{e}} / r_{\mathrm{en}}$	1.674 927 243 6135 x 10^{-24}	g
neutron Compton wavelength	$\lambda_{\pi \mathrm{C,n}}$	$\lambda_{\pi \mathrm{C,n}} = r_{\pi \mathrm{en}} \cdot \lambda_{\pi \mathrm{C}}$	1.319 590 908 0246 x 10^{-13}	sm
neutron-proton mass ratio	$r_{\pi \mathrm{np}}$	$r_{\pi \mathrm{np}} = r_{\pi \mathrm{ep}} / r_{\pi \mathrm{en}}$	1.001 378 419 179 999	
proton-neutron magnetic moment ratio	$r_{\pi\mu,\mathrm{pn}}$	$r_{\pi\mu,\mathrm{pn}} = \mu_{\mathrm{p}} / \mu_{\mathrm{n}}$	−1.459 898 124 622 978	
constant of scale invariance	ψ_{π}	$\psi_{\pi} = \kappa_{\pi e}^{6} \cdot f_{\pi s}^{3} \cdot 8\pi^{6} / \sqrt{\pi}$	1.669 642 831 928 814 x 10^{-23}	
Planck length	$l_{\pi \mathrm{P}}$	$l_{\pi \mathrm{P}} = \lambda_{\pi \mathrm{C}} \cdot \psi_{\pi} / \sqrt{2\pi}$	1.616 143 702 8696 x 10^{-33}	sm
Planck mass	$m_{\pi \mathrm{P}}$	$m_{\pi \mathrm{P}} = m_{\pi \mathrm{e}} / \sqrt{2\pi} \cdot \psi_{\pi}$	2.176 583 930 6611 x 10^{-5}	g

Quantity	Symbol	Formula (Pi-Theory)	Value (SGS)	Unit (SGS)
1	2	3	4	5
Planck time	$t_{\pi \text{P}}$	$t_{\pi \text{P}} = l_{\pi \text{P}} / c$	5.390 875 119 5790 x 10^{-44}	s
quantum of circulation	$q_{\pi c}$	$q_{\pi c} = \lambda_{\pi \text{C}} \cdot c$	7.273 895 109 4073	$\text{sm}^2\ \text{s}^{-1}$
Planck constant	h_π	$h_\pi = m_{\pi \text{e}} \cdot \lambda_{\pi \text{C}} \cdot c$	6.626 069 154 6014 x 10^{-27}	$\text{g sm}^2\ \text{s}^{-1}$
elementary charge	e_π	$e_\pi = \left(\kappa_{\pi e} \cdot h_\pi \cdot c\right)^{1/2}$	4.803 204 354 1649 x 10^{-10}	$\text{g}^{1/2}\ \text{sm}^{3/2}\ \text{s}^{-1}$
Newtonian constant of gravitation	G_π	$G_\pi = \hbar_\pi \cdot c / m_{\pi \text{P}}^2$	6.673 381 632 9142 x 10^{-8}	$\text{g}^{-1}\ \text{sm}^3\ \text{s}^{-2}$
Avogadro constant	$N_{\pi \text{A}}$	$N_{\pi \text{A}} = 1 / m_{\pi u}$	6.022 140 379 0140 x 10^{23}	g^{-1}

Table 3. In accordance with the list of data of table 2, shows the values FPC, of the recommended CODATA (2010) for international use - publication on the NIST website at: http://physics.nist.gov/cuu/Constants/index.html; the results of calculations from table 2; the results of data comparison are presented in column (6), δ_r – the relative uncertainty.

Parameter *a*, symbol CODATA	Value, (SGS) CODATA 2010	Relative std. uncert. u_r	Parameter *a**, symbol Pi-Theory	Value, (SGS) Pi-Theory	$\delta_r = \dfrac{a^* - \bar{a}}{\bar{a}}$
1	2	3	4	5	6
α	7.297 352 5698(24) x 10^{-3}	3.2 x 10^{-10}	α_π	7.297 352 572 519 857 x 10^{-3}	3.7 x 10^{-10}
a_e	1.159 652 180 76(27) x 10^{-3}	2.3 x 10^{-10}	$a_{\pi \text{e}}$	1.159 652 180 787 572 x 10^{-3}	0.2 x 10^{-10}
λ_C	2.426 310 2389(16) x 10^{-10}	6.5 x 10^{-10}	$\lambda_{\pi \text{C}}$	2.426 310 240 7357 x 10^{-10}	7.5 x 10^{-10}
r_e	2.817 940 3267(27) x 10^{-13}	9.7 x 10^{-10}	$r_{\pi \text{e}}$	2.817 940 329 8407 x 10^{-13}	11.1 x 10^{-10}
a_0	0.529 177 210 92(17) x 10^{-8}	3.2 x 10^{-10}	$a_{\pi 0}$	0.529 177 211 1187 x 10^{-8}	3.7 x 10^{-10}
m_e	9.109 382 91(40) x 10^{-28}	4.4 x 10^{-8}	$m_{\pi \text{e}}$	9.109 382 325 3402 x 10^{-28}	−6.4 x 10^{-8}
m_e / m_p	5.446 170 2178(22) x 10^{-4}	4.1 x 10^{-10}	$r_{\pi \text{ep}}$	5.446 170 218 699 091 x 10^{-4}	1.6 x 10^{-10}
m_p	1.672 621 777(74) x 10^{-24}	4.4 x 10^{-8}	$m_{\pi \text{p}}$	1.672 621 669 8229 x 10^{-24}	−6.4 x 10^{-8}
$\lambda_{\text{C,p}}$	1.321 409 856 23(94) x 10^{-13}	7.1 x 10^{-10}	$\lambda_{\pi \text{C,p}}$	1.321 409 857 4420 x 10^{-13}	9.1 x 10^{-10}
m_e / m_n	5.438 673 4461(32) x 10^{-4}	5.8 x 10^{-10}	$r_{\pi \text{en}}$	5.438 673 446 906 119 x 10^{-4}	1.4 x 10^{-10}
m_n	1.674 927 351(74) x 10^{-24}	4.4 x 10^{-8}	$m_{\pi \text{n}}$	1.674 927 243 6135 x 10^{-24}	−6.4 x 10^{-8}
$\lambda_{\text{C,n}}$	1.319 590 9068(11) x 10^{-13}	8.2 x 10^{-10}	$\lambda_{\pi \text{C,n}}$	1.319 590 908 0246 x 10^{-13}	9.2 x 10^{-10}
m_n / m_p	1.001 378 419 17(45)	4.5 x 10^{-10}	$r_{\pi \text{np}}$	1.001 378 419 179 999	0.1 x 10^{-10}
$\mu_\text{p} / \mu_\text{n}$	−1.459 898 06(34)	2.4 x 10^{-7}	$r_{\pi \mu,\text{pn}}$	−1.459 898 124 622 978	0.4 x 10^{-7}
l_P	1.616 199(97) x 10^{-33}	6.0 x 10^{-5}	$l_{\pi \text{P}}$	1.616 143 702 8696 x 10^{-33}	−3.4 x 10^{-5}
m_P	2.176 51(13) x 10^{-5}	6.0 x 10^{-5}	$m_{\pi \text{P}}$	2.176 583 930 6611 x 10^{-5}	3.4 x 10^{-5}
t_P	5.391 06(32) x 10^{-44}	6.0 x 10^{-5}	$t_{\pi \text{P}}$	5.390 875 119 5790 x 10^{-44}	−3.4 x 10^{-5}
h / m_e	7.273 895 1040(47)	6.5 x 10^{-10}	$q_{\pi c}$	7.273 895 109 4073	7.4 x 10^{-10}
h	6.626 069 57(29) x 10^{-27}	4.4 x 10^{-8}	h_π	6.626 069 154 6014 x 10^{-27}	−6.2 x 10^{-8}
e	4.803 204 27(12) x 10^{-10}	2.5 x 10^{-8}	e_π	4.803 204 354 1649 x 10^{-10}	−1.7 x 10^{-8}
G	6.673 84(80) x 10^{-8}	1.2 x 10^{-4}	G_π	6.673 381 632 9142 x 10^{-8}	0.6 x 10^{-4}
N_A	6.022 141 29(27) x 10^{23}	4.4 x 10^{-8}	$N_{\pi \text{A}}$	6.022 140 379 0140 x 10^{23}	15.1 x 10^{-8}

Based on the above, it seems true to assume that the proposed analytical method high-precision determination of values of the fundamental physical constants will allow to emerge from the theoretical impasse in the sphere of fundamental metrology.