The Fine-Structure Constant in Unknown Relations

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Abstract: Formulas for the fine structure constant are presented: speculative, well-known and ten original ones, four of which are related to quarks.

1. The Fine-Structure Constant in Speculative Formula

Ideja da se konstanta fine strukture ***α,*** or its inverse ***ά,*** can be expressed solely in terms of mathematical constants is widespread in literature and on the internet. There are numerous speculative and naive examples, coming from both amateurs and recognized scientific authorities. Let us mention just this example [1].

$$\alpha' = 4\pi^3 + 4\pi^2 + \pi^1 = \pi\left(4\pi^2 + 4\pi + 1\right) = 137.0363037 \qquad \textit{(1)}$$

Approximate values obtained using formulas that involve only the mathematical constants ***e*** and ***π*** are shown above. However, despite their elegant appearance, these formulas—both mine and the previous ones—lack mathematical and physical justification, and therefore will be presented as speculative, with the aim of illustrating the various ways in which one can arrive at an approximate value of this constant.

$$\alpha' = \left[e^{2\pi} + 4\pi + 1/4\pi + 1/(4\pi)^2 + 1/(8\pi)^3\right]/4 = 137.035999794 \qquad \textit{(2)}$$

$$\alpha' = \left[e^{2\pi} + 4\pi + 1/4\pi + 1/(4\pi)^2 + 1/129^2\right]/4 = 137.035999069 \qquad \textit{(3)}$$

$$\alpha' = \left[e^{2\pi} + 4\pi + 1/4\pi + 1/(4\pi)^2 + 1/(8\pi + \pi/8 - 1/e^{2\pi})^3\right]/4 = 137.035999075 \qquad \textit{(4)}$$

2. The Fine-Structure Constant in Relations between Physical Constants

The fine-structure constant (Alpha) is a dimensionless ratio between physical quantities, and aften ***2π,*** it is the most frequently used constant in physics. There are numerous formulas in which this constant appears; here, we will present some of them. The ones marked in blue font are previously unknown. In the table—segments of which have been '*copy/paste*' into this article—the input constants are given in the SI (MKS) system of units. Constants marked in red font are defined constants.

ά – Inverse fine-structure constant, **μ** – Proton-to-electron mass ratio,
h – Planck's constant, **c** – Speed of light,
T – Tau-to-muon mass ratio, **pr** – Proton mass, **ne** – Neutron mass,
γ – Neutron-to-proton mass ratio,
β – Ratio of classical electron radius to the proton Compton wavelength,
r_f – Fundamental limit, **m_f** – Mass of a fundamental particle,
q_{pl} – Planck charge, **$1/R_\infty$** – Inverse of the Rydberg constant,

l_{pl} – Planck length, **m_{pl}** – Planck mass,
G – Newton's gravitational constant, **K_j** – Josephson constant [$L^{-0.5}$ $M^{-0.5}$],
R_k – von Klitzing constant (electrical resistance), **k_B** – Boltzmann constant,
λ_p – Compton wavelength of the proton,
$m_{R\infty}$ – Equivalent mass of the Rydberg cohesion radius,
r_{ce} – Classical electron radius, **M_u** – Mass of the universe,
m_H – Energy/mass of the hydrogen atom ground state,
a_0 – Bohr radius, **$ά_G$** – Gravitational coupling of the electron,
σ – Stefan–Boltzmann constant,
$σ_R$ – Radiation constant for blackbody radiation,
q, Δp, ξ, S – Derived dimensionless constants used to simplify formulas.

Table – Formulas for Alpha

	constants		constants	
	$2\pi =$	6,28318531	$e^{2\pi}=$	535,491655525
	$ά =$	137,035999084	$k_B =$	1,38065E-23
	$\mu =$	1836,152673430	$\hbar = h/2\pi$	1,05457182E-34
	$h =$	6,62607015E-34	$G = c^{2} * l_{pl} / m_{pl}$	6,67383542E-11
	$c =$	2,99792458E+08	$\lambda_p = h/(pr*c)$	1,32140986E-15
	$pr =$	1,67262192369E-27	$m_{pl} =$	2,17651009E-08
1	$T = m_\tau / mu =$	16,8167350604176	$m_{R\infty} =$	8,65787664E-14
	$m_{el} = pr/\mu$	9,10938370155E-31	$r_{ce} =$	2,81794033E-15
	$ne =$	1,67492749787E-27	$M_u =$	1,73944927E+53
			$q=3*e^{2\pi}/4+3\log_2(2\pi)/2-\Delta p/2$	404,628455366
	$\gamma = ne/pr =$	1,00137841920	$\Delta p=2-1/(2\pi\beta+2)$	1,93506094
	$\beta=r_{ce}/\lambda_p=\mu/2\piά$	2,13252559E+00	$\xi=2^{(4/3-1/(3\pi\beta+3))}/\beta$	1,14669171435
	$r_f = \lambda p\ 2^{(2\Delta p/3)}$	3,23130882E-15	$m_f = pr*2^{(-2\Delta p/3)}/2\pi$	1,08862171E-28
		Vodonik (13.6 eV)	$m_H = m_e/2ά^2$	2,42543510E-35
	$q_{pl}=(r_f*m_f)^{0.5}*c$	1,77806827E-13	$e=c(m_e r_e)^{0.5}$	1,51890670E-14
	$1/R_\infty=4\pi*ά*a_0=$	9,1126705058E-08	$a_0=ά*r_f*m_f/m_{el}$	5,29177211E-11
	$l_{pl} = r_f*2^{q/6}$	1,61619877204E-35	$ά_G=G*m_e^{2}/(\hbar c)$	1,75168746E-45
	$K_j=2e/h =$	4,584638E+19	$R_k=h/e^2$	2,87206217E-06
			$ά_R=1/e^2(4σ/ck_B^4)^{1/3}$	157,554873613
			$σ=(2\pi)^5 k_B^4/(16*15*c^2h^3)$	5,6703744E-08

Known formulas for ά =

			$Gm_{pl}^2/e^2=$	137,035999084
	$\sqrt{(c^2 m_e a_0/e^2)}$	137,035999084	$4c/(2\pi h K_j^2) =$	137,035999084
2	$\hbar/(c*m_{el}*r_{ce})$	137,035999084	$c\hbar/e^2 =$	137,035999084
	q_{pl}^2/e^2	137,035999084	$\alpha_G^{1/2} a_0/l_{pl} =$	137,035999084
	$1/(4\pi R_\infty * a_0)$	137,035999084	$m_e c a_0/\hbar =$	137,035999084
	$l_{pl} m_{pl}/(r_e m_e)$	137,035999084	$ά_R \pi^{2/3}/15^{1/3} =$	137,035999084

3. The Fine-Structure Constant in Previously Unknown Relations

For the following formulas, which use input data from the previous table, we will not discuss the domain of their application, as such divisions are artificial and the Universe functions as a ***unity of the whole and its parts***. The results are based on data from the CODATA year 2018 [5], and the formulas actually represent the third segment of the previous table.

Based on the knowledge of the fundamental particle [2], the following is the basic formula for ***ά*** related to it, and all the formulas from the previous second segment can, through substitutions, be reduced to formula ***(5)***:

$$\alpha' = r_f * m_f / \left(r_{ce} * m_{el}\right) = l_{pl} * m_{pl} / \left(r_{ce} * m_{el}\right) \qquad \textbf{(5)}$$

Although formula (***6***) is essentially known, it is not commonly used because the ratio of the classical electron radius to the Compton wavelength—denoted as **β**—cannot be determined experimentally. Nevertheless, this very ratio holds key significance for the proton, and therefore for everything else as well.

$$\alpha' = \mu / \left(2\pi\beta\right) \qquad \textbf{(6)}$$

In formula (***7***), m_H represents the energy of the hydrogen atom's ground state (13.6 eV) converted into mass.

$$\alpha' = \left[m_{el}\left(2 * m_H\right)\right]^{1/2} \qquad \textbf{(7)}$$

Thanks to the sorting in the table, in formula ***(8)*** we obtained the highest exponent over Alpha, „***9***“, which does not appear even remotely in any known physics formula. The equivalent mass of the Rydberg non-cohesive radius $m_{R\infty}$ was obtained through the Theory of R. Bošković [3]:

$$\alpha' = \left[\xi^3 * m_{R\infty} / \left(32 * \pi^2 * \mathrm{m}_H\right)\right]^{1/9} \qquad \textbf{(8)}$$

The significance of formula ***(9)*** lies in the fact that it connects the neutron, proton, and electron, which are the key and almost exclusive constituents of the universe.

$$\alpha' = \left[q / \left(\log_2 \gamma - 1\right) / \log_2 \mu\right]^{1/2} \qquad \textbf{(9)}$$

Formula (***10***) is actually a differently written, improved Koide formula [4], in which the measured value of the muon mass [5] and the Tau mass $\mathbf{m_\tau = 3.1674852349 \times 10^{-27}}$ **kg** are used. Solving this formula for **ά** using logarithmic values in relation to the mass of the universe (***τ, μ, e, n, e.g., $\tau = \log_2(M_u/m_\tau)$***) enables the application of formula (***10***).

$$\alpha' = \left\langle \left[\left(2^{el} + 2^{mu} + 2^{\tau}\right) / \left(2/3 + \frac{1}{f * \pi}\right) \right]^{1/2} - \left[2^{mu/2} + 2^{\tau/2}\right]^2 \right\rangle \qquad \textbf{\textit{(10)}}$$

We will not comment in detail on the significance and properties of these formulas, as we believe this deserves a separate paper. However, it is worth noting that in the formulas, not only the constants change but also the mathematical operations. From Table 21, it can be observed to what extent the formulas correspond to the input data. Neutrinos are not included in the analysis, nor is their connection to the fine-structure constant clear, while such a connection does not exist for bosons. Additionally, this constant appears in all complex structures, and most likely in cosmological frameworks as well.

4. The Fine-Structure Constant in Quark Relations

The fourth segment of the table represents the result of a heuristic and rational approach, where we obtained the values of the second- and third-generation quark masses using the following formulas:

Continuation - Formulas for Quark Masses

$\mathbf{m=\beta^{\wedge -2/3} * 2^{\wedge(8*\Delta p/9)} * m_f}$ ***2,164722E-28***

	Quarks	*mass [kg]*	*[MeV/c²]*	*[MeV/c²]*
	$\mathbf{t=m* [T*(\acute{\alpha}-1)^{4}*2^{-1}]^{1/3}}$	**3,0797190E-25**	**172,7596**	172.76 ± 0.3
4	$\mathbf{b=m*(T^{\wedge -1}*\acute{\alpha}^{\wedge 4}*2^{\wedge -9})^{\wedge(1/3)}}$	**7,4618137E-27**	**4,1858**	4.18 +0.04; −0.03
	$\mathbf{c=m*(T*\acute{\alpha}*2^{\wedge -1})^{\wedge(1/3)}}$	**2,2694338E-27**	**1,2731**	1.275+0.025; −0.035
	$\mathbf{s=m*(T^{\wedge -1}*\acute{\alpha}*2^{\wedge -4})^{\wedge(1/3)}}$	**1,7287269E-28**	**0,0970**	95 +9; −3 [GeV/c²]

We have labeled the masses with the initial letter of the quark's name for space-saving purposes. The constant mass ***m*** appears for all quarks, and the continuation of the table is in ***[kg]***, with the results converted into generally accepted units for comparison with measured data from the literature in the last column. In the table, the formula for the top quark looks unusual, which will be clarified in the next segment 5, where solving for **ά** yields previously unknown formulas for **ά** in relation to the quarks. Instead of ***m***, by simplifying, we find that the dimensionless constant ***S*** is more convenient for representation.

Continuation - Unknown formulas with quarks for ά =

$\boldsymbol{S = (2\pi)^{\wedge 3} * \beta^2 / 2^{\wedge(2*\Delta p/3)}}$ **461,303958296**

	$\boldsymbol{(2*(t/pr)^{\wedge 3}* S / T)^{\wedge 1/4}+1}$	**137,035999084**
5	$\boldsymbol{(2^{\wedge 9}*(b/pr)^{\wedge 3}*S * T)^{\wedge 1/4}}$	**137,035999084**
	$\boldsymbol{2 * (c/pr)^{\wedge 3}* S / T}$	**137,035999084**
	$\boldsymbol{2^{\wedge 4}* (s/pr)^{\wedge 3}* S * T}$	**137,035999084**

The formula obtained by combining four formulas for quarks is presented in mathematical form, (*11*). The formula $\boldsymbol{m_t = \pi * 2^{\wedge 8\Delta p/9} * \beta^{\wedge -2/3} * (T * \acute{\alpha}^4 * 2^{\wedge -6})^{\wedge 1/3}}$ is more elegant for the top quark because it does not contain (ά⁻¹), but it does not satisfy formula ***(11)***, which is an indicator that the formula from segment 4 is, in fact, the correct solution.

$$\alpha' = 2^{5/4} * \left[S * (\mathrm{c*s})^{3/2} / pr^3 + S^{1/2} * (\mathrm{t*b})^{3/4} / pr \right]^{1/2} \qquad \textbf{\textit{(11)}}$$

The formulas for quarks use key constants ***2, π, ά, β***, as well as the assumed constant ***Δp***, which is also related to ***β*** and here shows its practical value. Formula ***(11)*** unifies a similar to The Improved Koide formula for charged leptons, except here, instead of three, we have two terms in parentheses. In the parentheses, a noticeable difference can be seen between the terms corresponding to the second and third-generation quarks. This formula could spark a discussion on the relationship between quark and lepton masses.

5. Is the Fine-Structure Constant Variable?

Here, we only present a hypothesis, which is in line with the latest measurements and what we know about constants, especially the transcendence of ***2π***. We consider the expression ***2π*ά*** to be a more consistent physical constant than its individual components—where ***2π*** naturally 'cancels out' in physical formulas. Accordingly, the ratio ***μ/β***, related to the proton and electron in formula (6), is also more consistent. From this, the temporal and spatial variations of the constant ***ά*** naturally arise.

References:

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