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A compact means of generating the fine structure constant, as well as three mass ratios

J. S. Markovitch

P.O. Box 2411, West Brattleboro, VT 05303
Email: jsmarkovitch@yahoo.com

Abstract

A function useful for compactly reproducing the experimental values of the fine structure constant, as well as the neutron-, muon-, and tau-electron mass ratios, is described. The first three of these values are reproduced with errors of 1.1, 1.2, and 23 parts per billion, respectively.

Define

$$f(a,b) = \frac{10^{\frac{5+a}{2}} - 10^{-3}}{3^{2+b}} - 10^{-3} \quad , \tag{1}$$

so that the fine structure constant inverse $\frac{1}{\alpha}$, as well as the muon-, and neutron-electron mass ratios, may be reproduced as follows:

$$\frac{1}{\alpha} \approx 100 + f(1,1) = 137.036 \quad , \tag{2a}$$

$$\frac{M_n}{M_e} \approx 100 \times \frac{(4.1)^3 + 6 \times 10^3}{f(1,-1)} + \frac{6 \times 10^3}{f(1,-1)} = 1838.68365473... \quad , \tag{2b}$$

$$\frac{M_\mu}{M_e} \approx 100 \times \frac{(4.1)^3 - (0.1)^3}{f(-1,-1)} = 206.76827073... \quad . \tag{2c}$$

These calculated values differ from their 2002 CODATA values of 137.03599911, 1838.6836598, and 206.7682838, by 6.5, 2.8, and 63 parts per billion (ppb), respectively [1].

Furthermore, substituting

$$f'(a,b)=\frac{10^{\frac{5+a}{2}}-10^{-3}-10^{-6}-10^{-9}-10^{-12}-\ldots}{3^{2+b}}-10^{-3}-10^{-6}-10^{-9}-10^{-12}-\ldots\ , \quad (3)$$

for $f(a,b)$ refines the above calculated values to 137.03599896..., 1838.68366209..., and 206.76827901, while reducing their respective errors to just 1.1, 1.2, and 23 ppb. (Note that the one-standard-deviation uncertainties of these CODATA values are 3.3, 0.7, and 26 ppb, respectively [1].)

A key question raised by the above equations is whether their exactness is a product of arbitrary fine tuning. For the above precisely-known physical constants we will define fine tuning as the introduction of an arbitrary small term (or terms) designed to allow an equation to more closely fit experimental data.

Clearly, under this definition the expressions 10^{-3}, as well as $-10^{-3}-10^{-6}-10^{-9}-10^{-12}\ldots$, provide fine tuning within the functions $f(a,b)$ and $f'(a,b)$, respectively. But as this fine tuning is the same for all three constants, it cannot by itself account for the precise fit achieved for all three.

The only remaining term that fine tunes under the above definition is 10^{-3}, which appears in the numerator of the muon-electron mass ratio. But this value is not wholly arbitrary, firstly, because it already occurs twice in both $f(a,b)$ and $f'(a,b)$; and, secondly, because it fits naturally alongside 4.1^3, as shown by the following equation

$$\frac{M_\tau}{M_e} \approx 100 \times \frac{(4.1)^5 - (0.1)^5}{f(-1,-1)} = 3475.82.... \quad , \tag{4a}$$

which closely mirrors the form of Eq. (2b), while reproducing the experimental value for the tau-electron mass ratio to within about 1 part in 2,000 of its center value of 3477.48... . (Experimentally, the tau-electron mass ratio equals roughly $3477.48^{+0.57}_{-0.51}$ [1].) Moreover,

$$\frac{M_\tau}{M_e} \approx 10 \times \frac{(4.1)^5 - (0.1)^5}{f(-3,-1)} = 3477.07.... \tag{4b}$$

reproduces this experimental value to within its limits of error.

Taken overall, the above evidence suggests that the functions $f(a,b)$ and $f'(a,b)$ work for reasons that are physical, rather than accidental. Moreover, this issue has been examined in detail by the author using number theory (as it applies to the theory of approximations), as well as information theory [2], where the conclusion was reached that, even for the muon- and neutron-electron mass ratio equations considered in isolation, their joint compression of the experimental data is so large that their success is unlikely to be purely coincidental. In addition, the author has demonstrated that toroids dimensioned by powers of the values 4.1 and 0.1 possess surface areas proportional to the above particle masses, where the specific results achieved are similar to those of Eqs. (2a)-(2c) [3]. Lastly, the author has described two mass formula that reproduce key mass ratios for the quarks and leptons within a framework that automatically limits the number of particle families to three [4,5].

Endnote

Note that although Eqs. (2a)-(2c) exploit $f(1,1)$, $f(1,-1)$, and $f(-1,-1)$, respectively, none of the above equations exploits $f(-1,1)$. It is logical to ask if $f(-1,1)$ also has a use. The answer is that $4\times f(1,1)-3\times f(-1,1)=137.036$.

References

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