Prediction of the neutrinos masses using some empirical formulae

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(Dated: September 22, 2019)

Abstract

In a paper in year 2011 the author implicitly predicted the masses of the neutrinos using some old empirical formulae. Now this prediction is explicitly written, mass of one neutrino is calculated as 21.44240(50) meV, respectively 21.36459(49) meV, dependent of the model. (The other masses of the neutrinos are connected with one of these values.) According to the upper bounds of neutrinos masses in 2005, and respectively in 2019, the author calculates that the upper bound of the lightest neutrino mass approached between 3 times to 20 times to the predicted value in 2019 according to 2005. At the same time, cosmologists predict that in the next five years we will have values of the neutrino masses, not only the lower and upper bounds. Thus this prediction can be tested, and maybe p-value for accident will not be large. Besides, the prediction of the gravitational constant with the same formulae is also mentioned.

I. INTRODUCTION

Nowadays, *Quantum gravity theory* is still unexplained. The masses of the elementary particles are also unexplained, as well as the fine structure constant, etc.

Using guesswork, in year 1986 I found some formulae for the masses of the elementary particles.[1] Later, when I collected all possible arguments for my formulae, I found out that the principle of these formulae can be generalized also to the masses of the neutrinos.[2] (Eqs. (7), (8), (54) and (55)) Now, the first calculation of the upper bound of the mass of the lightest neutrino appeared,[3] therefore in this paper I wrote more explicitly what is my prediction of the mass of the neutrino and what is measured now about this. Besides, more precise measurements of the masses of the neutrinos can be expected in few years, not only upper bound of their masses.[4]

II. THE PREDICTION

The formula which is already implicitly written in Ref.[2] (Eqs. (7), (54) and (55)) is written here explicitly

$$\frac{(m_0^\nu)^2 G_\mathrm{N}}{\hbar c} = \exp\left(\frac{-1}{\alpha}\right) . \tag{1}$$

At this, it is respected that the gravitational constant and the fine structure constant have values

$$G_\mathrm{N} = 6.708\,61(31) \times 10^{-39}\ \hbar c\ (\mathrm{GeV/c^2})^{-2}\,,^{5}\ \text{(Sec. Physical Constants)} \tag{2}$$

$$\alpha = 1/137.035\,999\,139(31)\,,^{5}\ \text{(Sec. Physical Constants)} \tag{3}$$

and so it is obtained

$$m_0^\nu = 21.364\,59(49)\ \mathrm{meV}\,. \tag{4}$$

The correction of Eq. (8) according to Eq. (7) can be used, what means for the neutrino[6]

$$\frac{(m_0^\nu)^2 G_\mathrm{N}}{\hbar c} = (1+\alpha)\exp\left(\frac{-1}{\alpha}\right) . \tag{5}$$

This gives a slight change for the predicted mass of the neutrino

$$m_0^\nu = 21.442\,40(50)\ \mathrm{meV}\,. \tag{6}$$

Indexes for the neutrinos are explained in Ref.[4] (Sec. 2.2), and indexes for the lightest neutrino, m_0^ν, are explained in Ref.[3]. The most logical equations for m_0^ν are Eqs. (1) and (5), but if it is valid $m_0^\nu = 0$, then one of these two equations is valid for the next lightest neutrino. But in principle, this can be valid also for the second or for the heaviest neutrino.

This can be valid also for any other important combinations, for instance the lower bound of the mass of the β-neutrino is 0.01eV,[7] what is close to the calculations (4) and (6).[9] At this, it is necessary to know that physicists say that only masses m_1^ν, m_2^ν in m_3^ν have the fundamental meaning. But a clear model fails, therefore options are still open. But, because this is a prediction, the principle should be the same as in Ref.[2].

Eqs. (1) and (5) happened so that firstly other main formulae in Ref.[2] were known, i.e Eqs. (7) and (8), etc. Then the first measurements of differences between squares of masses of neutrinos appeared.[8] (Eq. (13.24), Fig. 13.1) I tested these differences so that I calculated $\ln(|\Delta m_{31}^2| G_\mathrm{N}/(\hbar c))$ and $\ln(\Delta m_{21}^2 G_\mathrm{N}/(\hbar c))$, and I compared obtained values -138.8 and -135.3 with $-1/\alpha$. The differences were small. I supposed that such calculation for the squares of the neutrino masses is also close to $-1/\alpha$. Then values for the upper and the lower bound for m_{ν_max} appeared, and they were 0.04 eV and 0.4 eV,[8] (Eqs. (13.37) and (13.38)), and I published this calculation in Ref.[2] (Eqs. (54) and (55)).

Now the calculation of the upper bound of m_0^ν appeared, its value is 85 meV.[3] This already means approaching to my prediction from 2011. Therefore, I wrote these predictions still more explicitly that I have a clear proof that I predicted this approaching, although it was predicted already in Ref.[2] (Eqs. (54) and (55)). One additional calculation appeared,[10] which is still closer to my prediction, but it is more aggressive, therefore it is less conservative, and it is not yet accepted for publication.

In table I it is shown how the calculations in 2019[3,10] approach to prediction in 2011. This my prediction uses calculations from 2005.[8] Calculations in 2010[11] are also enclosed, but they were not used at prediction in 2011. Of course, they are not better than calculations of measurements in 2005.[8]

Now in 2019, the upper bound of m_0^ν is 3 to 20 times closer to prediction than in 2005. This is dependent of how (more or less) conservative predictions are compared. Besides, a table for inverted hierarchy can be also created, but this estimation, 3 to 20 times, could not be essentially changed.

There are also widely accepted predictions that the masses of the neutrinos will be mea-

TABLE I. Presentation of the calculated upper bounds according to author's prediction. Author's estimations are in italic as well as author's predictions in the third and the fourth row. Calculations use only normal hierarchy.

year	m_0^ν/eV	$m_{\max}^\nu$/eV	$\sum_{i=1}^{3} m_i$/eV
2005[8]	$<(\mathit{0.1938(14)} - \mathit{0.3969(7)})^{\mathrm{a}}$	$<(0.2 - 0.4)$	$<(0.4 - 1)$
2010[11]	$\lesssim (\mathit{0.22484(25)} - \mathit{0.56594(10)})^{\mathrm{b}}$		$\lesssim (0.68 - 1.7)$
Prediction 2011[2]	$\mathit{0.02136459(49)}^{\mathrm{c}}$	*0.05424(-44+41)*	*0.09865(-48+46)*
Corrected prediction 2011[2]	$\mathit{0.02144240(50)}^{\mathrm{d}}$	*0.05427(-44+41)*	*0.09883(-48+46)*
2019[10]	$\lesssim \mathit{0.04045(-15+14)}$		$\lesssim 0.146$
2019[3]	<0.085		<0.261

[a] Quantities m_0^ν are calculated with much more digits than input quantity m_{max}^ν; the reason is that it is evident how small is difference between m_0^ν in m_{max}^ν.

[b] Quantities m_0^ν are calculated with much more digits than input quantity $\sum_{i=1}^{3} m_i$; the reason is that it is evident how values of m_0^ν are close to 1/3 of values of $\sum_{i=1}^{3} m_i$.

[c] From Eqs. (7), (54) and (55) in Ref.[2]

[d] From Eqs. (8), (54) and (55) in Ref.[2]

sured in the next five years, not only their upper and lower bounds.[4] For instance, professor Ofer Lahav (UCL Physics & Astronomy), co-author of the study[3] and chair of the UK Consortiums of the Dark Energy Survey and DESI said: "*It is impressive that the clustering of galaxies on huge scales can tell us about the mass of the lightest neutrino, a result of fundamental importance to physics. This new study demonstrates that we are on the path to actually measuring the neutrino masses with the next generation of large spectroscopic galaxy surveys, such as DESI, Euclid and others.*"[12]

I suppose that first measurements of neutrino masses will not be very precise. But, in the case that the measurements will agree with my predictions, I suppose that it will be a low probability that these formulae will not have physical background, therefore, p-value will be low.

III. CONCLUSION

In year 2011 I implicitly but clearly predicted the mass of the neutrino.[2] (Eqs. (7), (8), (54), (55)) Now in this paper, this mass is explicitly written, and it is shown that the upper bound is 3 times to 20 times closer to predicted mass than in 2005. Besides, cosmologists expect that a direct measurement of neutrino masses will appear in five year, not only lower and upper bounds. Therefore, this prediction could be tested in five years. When this paper was prepared, improved values for double-β decay[13] and upper bound for β decay[14] appeared.

At this moment, this is now the strongest test for the formulae.[2] In Ref.[2] (Sec. 7) I listed arguments for these formulae. For a reader who does not wish to deepen in the paper[2], the most powerful argument is (xx), this is similarity of formulae (7) in (9) in Ref.[2], although I found formula (7) when I did not know formula (9). This is a formula of 't Hooft, maybe also of Landau.[15,16] If nothing more, this can be also argument for formula (9).

Otherwise, Ref.[2] (Eq. (50)) predicted also improved value for $G_{\rm N}$. Atomic interferometry[17] gives lower value than other methods and it is closer to my prediction. Maybe this suspicion will be tested with the improved measurements with the atomic interferometry.

Appendix A: Some corrections or additions according to Ref.[2]

Corrections:

- Here I will write more precisely point (v) in Ref.[2] (Pg. 14): Formulae (7), (37) and (39) in Ref.[2] give a hint that the next lightest particle has factor 5/4. And then also 6/5, and this is limiting toward 1.

  But, this was tested so that $\ln\left(m^2 G_{\rm N}/(\hbar c)\right)$ of this particle is calculated, and, of course, the result was firstly compared with $-1/\alpha$. The first calculations for bounds $0.04 - 0.4$ eV showed that this is close to $-1/\alpha$, thus it was not necessary to test options 5/4, 6/5, etc. Therefore only one step was enough to obtain formulae[2] (Eqs. (54) and (55)).

- A comma after Eq. (16) in Ref.[2] must be ignored. It changes the meaning of the sentence.

Additions:

- At Ref.[2], connection with Refs. [9] and [10] is somewhat lost. Link at Ref. [10] gives Eq. (28), which is

$$\alpha^{-1} = \alpha_0^{-1} + \frac{N}{3\pi} \ln \frac{\Lambda^2}{m^2} = 137.036 \tag{A1}$$

  where $\alpha_0 = 1/(4\pi)$. Other parameters are also described there. But link in Ref. [9] is no more active.

- It is surprising that it appeared that the measurement of the neutrino mass can tests formulae in Ref.[2]. The test could be also be done with more precisely measured masses of some elementary particles. One important test could also be done with more precisely measured $G_{\rm N}$, for instance, with an atomic interferometer,[17] but it not yet achieved wished accuracy.

- At all this, I am aware that the principle of quarks contradicts to this principle of formulae, and that the Higgs boson somewhat contradicts to this principle. But, at least the electron and the neutrino are not connected to the quarks, and the neutrino mass is not yet connected to the standard model of elementary particles. Besides, although the Higgs boson creates elementary particles masses, this does not mean that it is the only parameter which creates their masses.

ACKNOWLEDGMENTS

Thanks to Matjaz Poljšak[18] and Mitja Rosina for formula (9) in Ref.[2]. Thanks to Mitja Rosina for information about the guessing of the Balmer series. Thanks to a person with nickname rbj, who suggested that variable gravitational constant alone does not exist. Thanks for various help also to Erika Bricelj.

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[1] J. Kokosar, "Formulae for the masses of elementary particles," Speculations in Science and Technology **18**, (1), 68 (1995).

[2] J. Kokosar, "Guessed Formulae for the Elementary Particle Masses, Interpretation and Arguments of Them and a New View on Quantum Gravity," viXra, 1–19 (2011); *preprint* `<vixra.org/abs/1103.0025>`.

[3] A. Loureiro, A. Cuceu, F. B. Abdalla, B. Moraes, L. Whiteway, M. McLeod, S. T. Balan, O. Lahav, A. Benoit-Lvy, M. Manera, R. P. Rollins, and H. S. Xavier, "Upper Bound of Neutrino Masses from Combined Cosmological Observations and Particle Physics Experiments," Phys. Rev. Lett. **123**, (8), 081301 (2019); *preprint* `<arxiv.org/abs/1811.02578>`.

[4] M. Gerbino and M. Lattanzi, "Status of neutrino properties and future prospects - Cosmological and astrophysical constraints," Front. Phys., **5**, no 70, 1–36 (2018).

[5] M. Tanabashi et al. (Particle Data Group), "The Review of Particle Physics (2019)," Phys. Rev. D **98**, 030001 (2018) and 2019 update; Look section: Physical constants *link* `<pdg.lbl.gov/2019/reviews/rpp2018-rev-phys-constants.pdf>`.

[6] This correction means that models (7) and (8) exclude between themselves.

[7] R. G. Hamish Robertson, "Direct probes of neutrino mass," Nuclear and Particle Physics Proceedings **265–266**, 7–12 (2015); *preprint* `<arxiv.org/abs/1502.00144>`.

[8] S. Eidelman et al. (Particle Data Group), "The Review of Particle Physics Archived 2005 Edition," Phys. Lett. B**592**, 1 (2004) and 2005 partial update for the 2006 edition; Look section: Neutrino mass, mixing, and flavor change; *link* `<pdg.lbl.gov/2005/reviews/numixrpp.pdf>`.

[9] In Ref.[12] this value is 0.02 eV. The lower bound is much more stable according to measurements than the upper bound, therefore four years do not means a big progress, therefore I suspect that value 0.02 eV is a mistake of Ref.[12].

[10] S. R. Choudhury, S. Hannestad, "Updated results on neutrino mass and mass hierarchy from cosmology with Planck 2018 likelihoods," arXiv, 1–25 (2018); *preprint* `<arxiv.org/abs/1907.12598>`.

[11] S. Eidelman et al. (Particle Data Group), "The Review of Particle Physics Archived 2005 Edition," Phys. Lett. B**592**, 1 (2004) and 2005 partial update for the 2006 edition. Look section: Neutrino mass, mixing, and flavor change *link* `<pdg.lbl.gov/2010/reviews/rpp2010-rev-neutrino-mixing.pdf>`.

[12] "Maximum mass of lightest neutrino revealed using astronomical big data," (2019); *link* <phys.org/news/2019-08-maximum-mass-lightest-neutrino-revealed.html>.

[13] M. Agostini et al., "Probing Majorana neutrinos with double-β decay," Science, **365**, (6458), (2019); *preprint* <arxiv.org/abs/1909.02726>.

[14] J. Urton, "KATRIN cuts the mass estimate for the elusive neutrino in half," PHYS.ORG (2019); *link* <phys.org/news/2019-09-results-mass-neutrinos.html>.

[15] G. 't Hooft, "A physical interpretation of gravitational instantons," Nuclear Physics B**315** (2), 517-527 (1989); *link* <igitur-archive.library.uu.nl/phys/2005-0622-152928/14728.pdf>.

[16] L. D. Landau, in *Niels Bohr and Development of Physics*, edited by W. Pauli (McGrawHill, New York, 1955); *link* Reference for this book [14] and an important Eq. (28) also in: <quarks.inr.ac.ru/2004/proceedings/FT/ritus.pdf>.

[17] M. Prevedelli, L. Cacciapuoti, G. Rosi, F. Sorrentino, and G. M. Tino, "Measuring the Newtonian constant of gravitation G with an atomic interferometer," Nature, **510**, 518–521 (2014).

[18] 1951-2005