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Empirical analysis of particle masses from PDG-2016

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Empirical analysis of particle masses from PDG-2016

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Abstract.
Scalar field is responsible for particle mass generation within the Standard Model. We show here the specific role of scalar and vector field masses among masses of other particles. It is described as a common "tuning effect" in particle masses with the parameters $\delta = 16m_e$, $m_e/3$ derived directly from CODATA relation between masses of nucleons and the electron m_e. Masses of both leptons could be expressed as QED correction $(\alpha/2\pi)$ of boson masses M_H, M_Z.

It was noticed by Y. Nambu [1] that the Standard Model "is theoretically unsatisfactory because a) the unification of forces is only partially realized; and b) there are too many input parameters, especially concerning the masses, which are not explained." We consider here an electron–based SM–development [2-6], derived from the fact that nucleons and the electron are stable particles, which determine the mass of the universe and are in the ratio (between their masses) very accurately evaluated in CODATA review as m_n/m_e=1838.6836605(11) [7]. We take into account a place of the nucleon mass between masses of other particles [2-6,8], the discreteness ("tuning effect") with the period $\delta = 16m_e$ close to doubled pion mass splitting.

Observed distribution of particle mass differences (Fig.1 [2]) contains maxima at integer values of δ, namely, k=2 (17 MeV), k=6 (48 MeV), k=13 (104 MeV = m_μ) and k=17 (142 MeV = $m_{\pi^\pm}$). Presence of a doublet at 1671-1687 MeV = $12m_\pi$ and the maximum at 3370 MeV = 24m_π means the existence of long-range correlations with $m_\pi = 17\delta$ which corresponds to n=115 for the nucleon mass found by Y. Nambu [9]. Shift of neutron mass from 115·16m_e - m_e accounts δm_n = 161.6491(6) keV equal to 1/8 of nucleon mass splitting δm_N=1293.3322(4) keV.

Exactly integer ratio $\delta m_N : \delta m_n$ =8.00086(3)≈8×1.0001(1) allows representation:

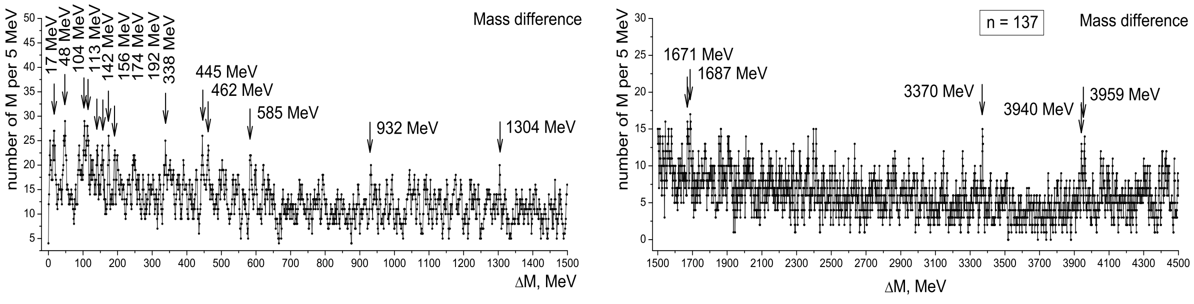

Figure 1. Distribution of differences between particle masses ΔM in regions 0-1500, 1500-4600 MeV.

$$m_n = 115 \cdot 16m_e - m_e - \delta m_N/8 \qquad\qquad m_p = 115 \cdot 16m_e - m_e - 9\delta m_N/8 \qquad (1)$$

The value of the shift is close to the QED radiative correction $\alpha/2\pi$=115.95·10^{-5} to the pion mass $\delta m_n/m_{\pi^\pm} = 115.82 \cdot 10^{-5}$ and coincides with the parameter Δ^{TF}=161 keV found in excitations of nuclei in which (according to T. Otsuka and I. Tanihata [10,11]) the one–pion exchange dynamics plays an important role. In Fig. 2 and Table 1 and 2 both parameters of the fine structure 161 keV=$17\delta'$ and 170 keV=$18\delta'$ observed in excitations of nuclei with valence nucleons [3,5] are presented as integers of the period δ=9.5 keV (integers n=13,14,16). In CODATA relation the shift of -m_e = -3·$m_e/3$ could be assigned to each of three quarks in the nucleon [2-6]. Parameters $\delta m_n = \delta m_N/8$ and $m_e/3$ are considered as the fine structure.

Table 1. Comparison of excitations E^* (in keV) in $Z = 51$ A-odd nuclei with integer numbers of Δ^{TF}=161 keV=(δm_N=1293 keV)/8 and close to δm_N intervals in 0^+-2^+-1^+ levels of ^{116}Sn (right, boxed).

^{A}Z	^{123}Sb	^{125}Sb	^{127}Sb	^{129}Sb	^{131}Sb	^{133}Sb	^{119}Sb	^{116}Sn	^{116}Sn
(N-70)/2	1	2	3	4	5	6		N=	66
E^*, keV	160.3	332.1	491.2	645.2	798.4	962.0	644	1294	1292
E^*-$\frac{\delta m_N}{8}$	-1	-9	+7	-1	-10	-7	-2	1	-1
n$\frac{\delta k_N}{8}$	161	323	484	646	808	969	646	1293	1293

An appearance of the same fine structure intervals 161 keV and 170 keV in nucleon mass representation and in nuclear data could be connected with the general character of all these QCD-based parameters and with position of the nucleon mass (in nuclear medium, m_N^{nucl} ≈932 MeV, Fig.3) among other above discussed stable mass interval ($m_\mu, f_\pi, m_\pi, \Delta M_\Delta$).

Distinguish stability of intervals ΔM with n=13 (m_μ) and n=17 (m_π) in Fig. 1 as an extension of the discreteness with stable splitting at 2δ and 6δ can be considered with the analogy between

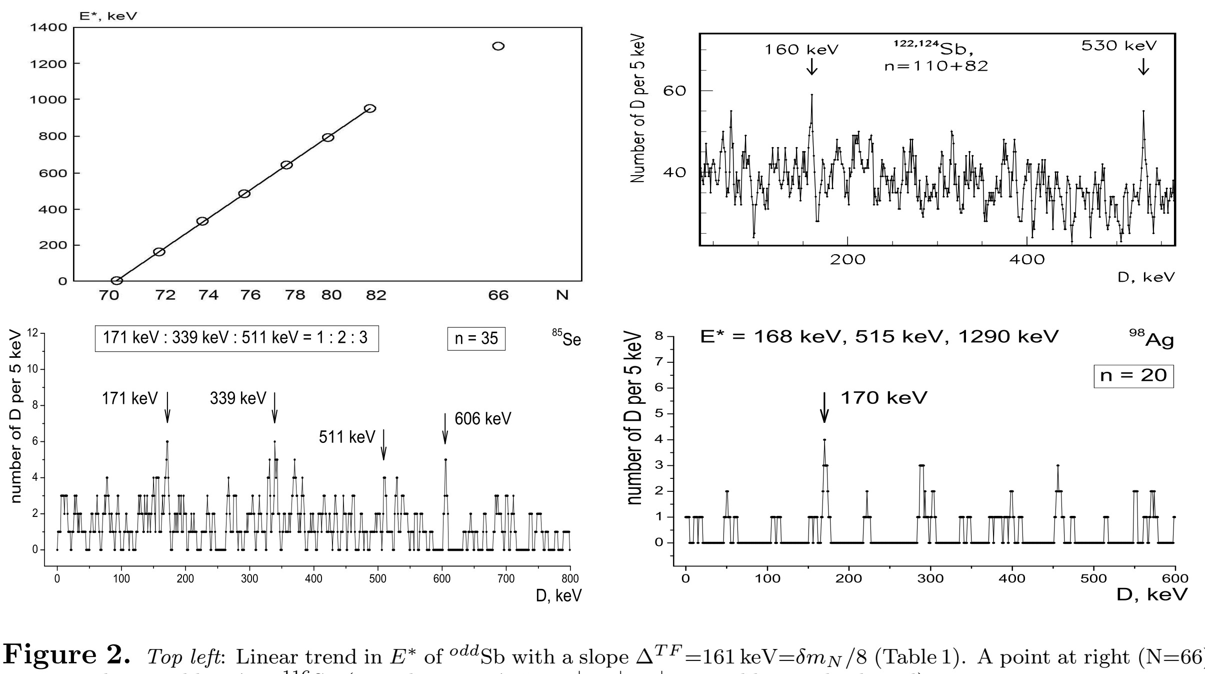

Figure 2. *Top left*: Linear trend in E^* of ^{odd}Sb with a slope Δ^{TF}=161 keV=$\delta m_N/8$ (Table 1). A point at right (N=66) corresponds to stable E^* in ^{116}Sn (equidistant E^* J^π=0^+, 2^+, 1^+ see Table 1, right, boxed).
Top right: Sum D-distribution in ^{122,124}Sb. Maxima at 160 keV=$17\delta'$ and 530 keV=4×$14\delta'$.
Bottom left: *D*-distribution in ^{85}Se (N=51); maxima at k×$18\delta'$, similar to E^* in ^{101,103}Sn (N=51,53, Table 2, left).
Bottom right: D-distribution in ^{98}Ag (N=51) with E^*=168, 515, 1290 keV, (Table 2, right).

Table 2. Excitations (in keV) in nuclei with Z=50,34,47, close to integers of $18\delta'$=170 keV=$m_e/3$. Integer numbers of $\Delta^{TF}=17\delta'$=161 keV=$\delta m_N/8$ and D in ^{85}Se are given in the center.

Z	50	50	50		34			34	47			47
N	51	53	83		51			50	51			50
^AZ	^{101}Sn	^{103}Sn	^{133}Sn		^{85}Se			^{84}Se	^{98}Ag			^{97}Ag
E^*	170	168	854	1363	170	339	511	1455	167.8	515	1291	1290
$2J^\pi$	7^+	$(7)^+$	3^-	3^-	D	D	D	2+	(3+)	2,3+	1,3+	13^+
$18\delta'$	170	170	851	1362	170	340	511	$(9/8)\delta m_N$	170	511	δm_N	δm_N

the lepton ratio $L = 207 \approx (m_\mu/m_e)$ and the number of fermions in the central field N,ferm. shown in the 1-st line of Table 3 [2-6]. Interval $\delta = 16m_e$ was taken from CODATA relation.

Relations 1:2:17, 1:3 and 1:12:24 between positions of maxima in Fig. 1, the muon and pion mass presentation (as 13×16-1 and 17×16+1) and maxima at ΔM=1687 MeV (n=12×17) and ΔM=3370 MeV (n=24×17) have traces of symmetry–motivated origin of the mass discreteness.

Table 3. Comparison of ratios between masses m_μ/M_Z, $f_\pi/(2/3)m_t$ and $\Delta M_\Delta/M_H$, QED parameter $\alpha/2\pi$ and numbers of fermions in the central field (central line, boxed in the bottom line is the hole configuration in $1p$ shell). One asterisk: configuration $1s^4_{1/2}$, $1p^8_{3/2}$, $1p_{1/2}$; two asterisks - configuration: new principal quantum number; three asterisks - configuration – $1s^4_{1/2}$, $1p^8_{3/2,1/2}$.

N ferm.	N = 1	N=16	16·13-1	16·16	16·17+1	16·18
Part./param.	m_e/M_q	δ	m_μ/M_Z	f_π/M'_H	$m_{\pi^\pm}$	$\Delta M_\Delta/M_H$
Ratio	$115.9 \cdot 10^{-5}$		$115.87 \cdot 10^{-5}$	$114 \cdot 10^{-5}$		$117 \cdot 10^{-5}$
Comments			hole in $1p$, *	filled shells, ***	(**)	

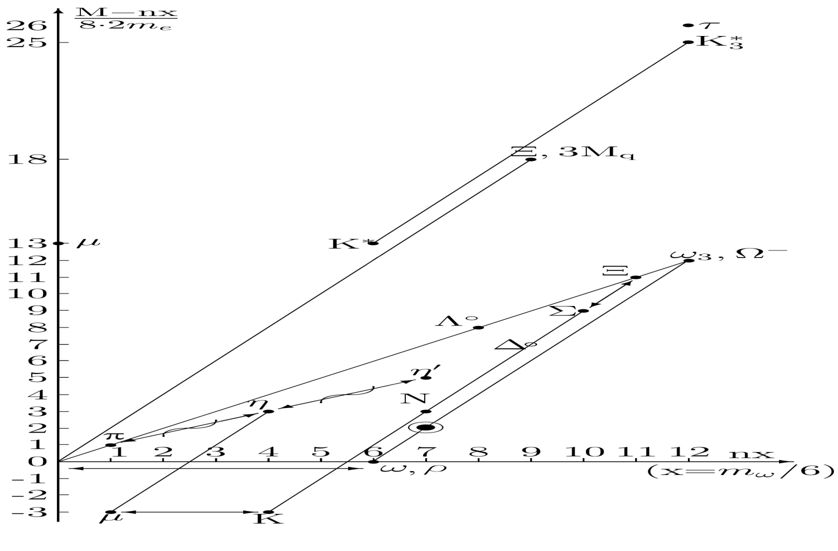

Figure 3. Evolution of baryon mass from $3M_q$ to Δ-baryon and nucleon masses is shown here in two-dimensional presentation: values on horizontal axis are in units $16 \cdot 16m_e = f_\pi$=130.7 MeV, remainders – M_i-n($16 \cdot 16m_e$) are along vertical axis in $16m_e$. Lines with three slopes correspond to three pion's parameters $f_\pi = 16\delta$, $m_{\pi^\pm} = 17\delta$ and $\Delta M_\Delta = 18\delta$. Line with m_π=140 MeV=$f_\pi+\delta$ (n=16+1) goes through masses of Λ, Ξ, Ω hyperons (=$8m_\pi$, $11m_\pi$, $12m_\pi$). Stable interval in pseudoscalar mesons $m_{\eta'}$-m_η=m_η-$m_\pi^\pm$ (crossed arrows), is close to M_q^Δ=410 MeV=50δ. Nucleon mass in nuclear medium (m_N^{nucl}, circled point) is close to sum $\Delta M_\Delta+6f_\pi$ which corresponds to important role of pion's parameters $f_\pi, \Delta M_\Delta$.

Table 4. Presentation of parameters of tuning effect in particle masses (three top sections) and in nuclear data (bottom, sections marked X = 0, 1 at left) by the expression n·16m$_e$($\alpha/2\pi$)^{X}M with QED correction $\alpha/2\pi$ (α=137^{-1}) [6].

X	M	n = 1	n = 13	n = 16	n = 17	n = 18	Comments
-1	3/2			m_t=172.0			
GeV	1	$16M_q=\delta^\circ$	M_Z=91.2	M_H=115 [10]		M_H=126	Part.
	1/2	(m_b-M_q)		M^{L3}=58 [9]			masses
0	1	$16m_e=2m_d$-$2m_e$	m_μ=106	f_π=130.7	m_π-m_e	ΔM_Δ=147	NRCQM
MeV	3			$M"_q=m_\rho/2$		M_q=441=ΔE_B	param.
1	1	$16m_e=\delta=8\varepsilon_\circ$			$k\delta$-m_n-m_e=	170 = $m_e/3$	Part.
					=161.651(6)		masses
keV	8				δm_N=1293.3		CODATA
1	1	$9.5=\delta'=8\varepsilon'$	123	152	Δ^{TF}=161	170 (Sn)	Nuclear
keV	3				484 (E^*)	512 (Pd)	data

In this work, we considered additional indirect confirmations (Tables 1,2) of the fine structure in CODATA relations (parameters 161 keV=$\delta m_N/8$ and 170 keV=$m_e/3$). The first parameter can be considered together with the mass of the pion due to a closeness of their ratio to $\alpha/2\pi$ which is shown in Tables 3,4 and was discussed in connection with the gravitation in [12-14].

We draw attention to the grouping effect in the mass differences at the value 932 MeV=$6f_\pi+\Delta M_\Delta$ close to the nucleon mass in nuclear media. Presence of similar effect at $M_q=3\Delta M_\Delta$, at $9M_q$, $10M_q$, $12m_\pi$ and $24m_\pi$ (Fig. 1) reflects the stability of intervals connected with the pion ($f_\pi, m_\pi, \Delta M_\Delta$, n=16,17,18). Small splitting within such groupings allowed to confirm general character of mass discreteness connected directly with the electron rest mass $\delta = 16m_e$ (as a cumulative effect with the value $m_e/3$). Interconnection between m_e and QED correction $\alpha/2\pi$ was suggested by R. Feynman, V. Belokurov and D. Shirkov. Presence of a single dynamics of mass generation which follows from exact CODATA relation and includes boson masses (Tables 3,4) allows to construct the "new physics" with existing SM–parameters.

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