The QED corrections in the Standard Model

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Abstract. The radiative correction as a commonly used methods of a comparison of the effects with different scales is known, for example, as Schwinger QED correction $\alpha/2\pi = 1.159\cdot10^{-3}$. It was found that the ratio between known Standard Model parameters m_μ/M_Z=1.159 10^{-3} coincides with QED correction, while the lepton ratio m_μ/m_e=206.77 becomes integer 207.01 after small QED correction for the electron rest mass. We follow Nambu suggestion that empirical relations in particle masses could be useful for the SM-development and consider empirical relations in well-known particle masses, including top-quark and tau-lepton. Indirect confirmation of the tuning effects in particle masses was found in the analysis of nuclear data.

1. Introduction

The radiative correction (of the type $g/2\pi$) is one of the commonly used methods of a comparison of the effects with very different scales [1]. For example, Bernstein marked [2] the closeness of the QED radiative correction ($\alpha/\pi=2.32\cdot10^{-3}$) to the parameter of CP-nonconservation in kaon decay η = $2.23\cdot 10^{-3}$ [3]. Here $\alpha/2\pi = 1.159\cdot10^{-3}$ is the well-known Schwinger QED radiative correction of the magnetic moment of the electron [3]. Application of such small QED correction to the mass of electron was discussed by Shirkov [4].

It was found in 70-ties [5,6] that: (1) the electromagnetic mass splitting of the pion δm_π is close to $9m_e$ = 4.599 MeV = Δ and (2) the accurately known lepton ratio m_μ/m_e=206.77 becomes integer 207.01 (L=207=9×23=13×16-1) after the application of this QED correction of the electron rest mass $m^*_e= m_e(1- \alpha/2\pi)$. The recent accurately measured value δm_π = 4.954(1) MeV [3] also is in an integer relation with m_e^* (namely, $\delta m_\pi/m_e^*$ = 9.00). We discuss here a possible origin of this relation m_e:δm_π:m_μ = 1:9:(L = 16×13-1) in the well known particle masses and the role of the QED radiative correction of the type $\alpha/2\pi$. We use here empirical fact that the ratio between the two well known SM-parameters: μ-lepton mass and Z-boson mass form a ratio (m_μ =105.66 MeV)/(M_Z=91187 MeV) = 1.159×10^{-3} coinciding with the QED correction ($\alpha/2\pi$). We consider other corresponding values in this 1:9:L relation.

It was found in 70-ties that the doubled value of the pion mass splitting (without m_e), that's the value $2(\delta m_\pi - m_e)$ or the doubled value of the pion β-decay energy is close to $16m_e = \delta$ and forms with pion mass itself integer ratio ($m_{\pi\pm} - m_e$=139.57-0.51.MeV)/2(δm_π- m_e) =17.03 while with the μ-lepton mass it forms the ratio ($m_\mu+m_e$=105.66+0.51MeV)/2(δm_π -m_e) = 13.00. The introduction of the period $\delta=16m_e$ permitted a simultaneous description of many other important mass parameters [6-9]. Among them:

(1) The nucleon Δ-excitation, namely, m_Δ-m_N=294 MeV=2 ×147 MeV = 2×Δ M_Δ =2 × 18 δ;
(2) Constant interval between scalar meson masses: $m_{\eta'}$ - m_η = 409.8 MeV, m_η-m_π = 408.3 MeV=50 δ;

(3) Introduced by Wick stable mass interval equal to ½ of ω - meson mass M''_q=391 MeV=3· 16 δ;
(4) Introduced by Sternheimer/ Kropotkin [10,11] mass interval equal to 1/3 of Ξ-baryon 441 MeV =3×147 MeV=3×18δ; intervals M''_q=391 MeV and M_q=441 MeV are standard estimates of the constituent quark masses in Constituent Quark Models (CQM, for example M_d=436MeV in [12]);
(5) Noticed by Nambu and others [6,20] closeness of masses to $k \times m_\pi$ or $k \times \Delta M_\Delta$ (k-integer, Table 1).

2. Nucleon structure and constituent quark masses

The constituent quark mass estimate as 1/3 of Δ-baryon mass M^Δ_q=410MeV is close to a stable interval in masses of pseudoscalar mesons $m_\eta - m_\pi^\pm \approx m_{\eta'} - m_\eta \approx 409$ MeV and to the sum $m_\pi^\pm + 2m_\pi^0$ = 409.5 MeV (corresponding to 17 + 33 = 50 periods of δ) [10,6,14], shown as crossed arrows in Fig.2..

The Δ-baryon mass is somewhat less than the initial baryon mass in the usual calculations of baryon masses in the NRCQM (Non-relativistic Constituent Quark Model). It is seen in Fig.1 [13] where calculations with CQM with Goldstone Boson Exchange are presented as a function of the strength of residual quark interaction. The observed nucleon Δ -excitation (294MeV) is shown as a difference of the observed masses marked "Δ" and "N" on the vertical line in the left picture. The initial non-strange baryon mass $M^{init}_N \approx$1350MeV in this CQM calculation is marked as "+" on the left axis. Corresponding value of the quark mass $M_q = (1/3)M^{init}_N \approx$ 450MeV is close to the three-fold value of the parameter ΔM_Δ of the Δ-excitation per one quark 441MeV=3(294MeV/2=147MeV=ΔM_Δ) and M_q=441MeV introduced by Sternheimer/Kropotkin from an equality of $m_\Sigma - m_N = m_N - m_K$, $m_\eta - m_\mu$ etc.

Recent progress in lattice QCD calculations and in application of Dyson--Schwinger Equations (DSE) [15,16] results in the understanding of the role of the gluon quark-dressing effect and interconnection between the relatively small values of the initial "chiral quark masses" $m_q \approx m_\pi/2$=70MeV (introduced earlier in [17]) and the large values of constituent quark masses $M^\Delta_q \approx$441MeV=M_q in NRCQM [12,13]). This QCD quark-dressing effect as the dependence of the dressed-quark mass function M(p) is shown as the top curve for the initial quark mass m_q=70MeV..

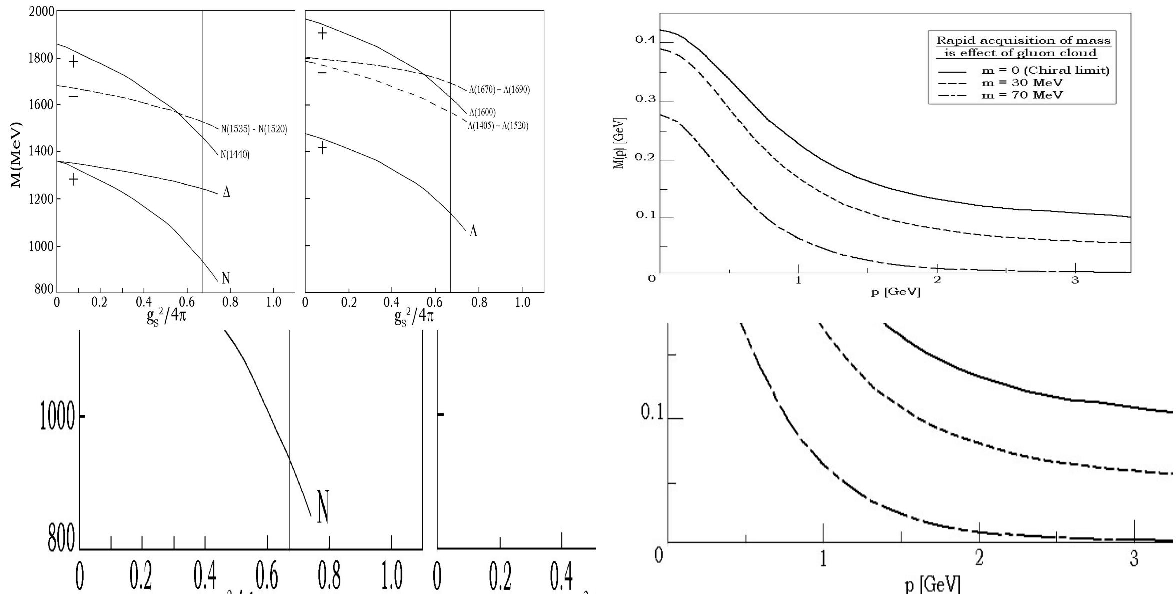

Figure 1. *Left*: Calculation of nonstrange baryon and Λ-hyperon masses as a function of interaction strength within Goldstone Boson Exchange Constituent Quark Model [13]; the initial baryon mass 1350MeV=3× 450 MeV=3M_q is marked "+" on the left vertical axis. *Right*: QCD gluon-quark-dressing effect calculated with DSE [16], initial masses m_q = 0 (Bottom), 30 MeVand 70 MeV (*Top*).

Table 1. Discussed in the literature closeness of masses [3] and mass differences to the integer numbers (k) of the pion mass $m_\pi^{\pm}$=139.5MeV or to $2m_\pi^0+m_\pi^{\pm}=\varkappa_\tau$=409MeV [14,18] (left part of the table and the line in Fig. 2 started at m_π and going throw the Lambda hyperon); the same effect with the integer numbers (k) of the parameter ΔM_Δ=147MeV=M_q /3 (at right, it is shown in Fig.2 as lines with a larger slope parallel to the intervals in vector meson masses of 884 MeV = 6 ΔM_Δ (ΔJ=2).

Particle	Λ	Ω	(bb) (2S-1S)	(bb) (4S-2S)	ΔE_B	(cc) (2S-1S)	(cc) (1S)	Ξ	ω_3-ω	K_3*-K*	ΔE_B
Mass	1115.7	1672	10023	10579	408.9	3686	3096.9	1321.3	1667	1776	441.5
(MeV)			-9460	-10023		-3097			-783	-892	
ΔM			=563	=556	k_τ	=589.2			=884(4)	=884(7)	
	k=8	k=12	k=4	k=4		k=4	k=21	k=9	k=6	k=6	k=3
km_π	1116	1674	558	558	409						
$k\,\Delta M_\Delta$						588	3087	1323	882	882	441
Diff.	0	2	≈5	≈2	0	1	10	-2	2(4)	2(7)	0
Ref.	[6,20]	[14,18]	[3,18]	[3,18]	[14,18]	[3,18]	[3,18]	[11,18]	[3,18]	[8,18]	[14,18]

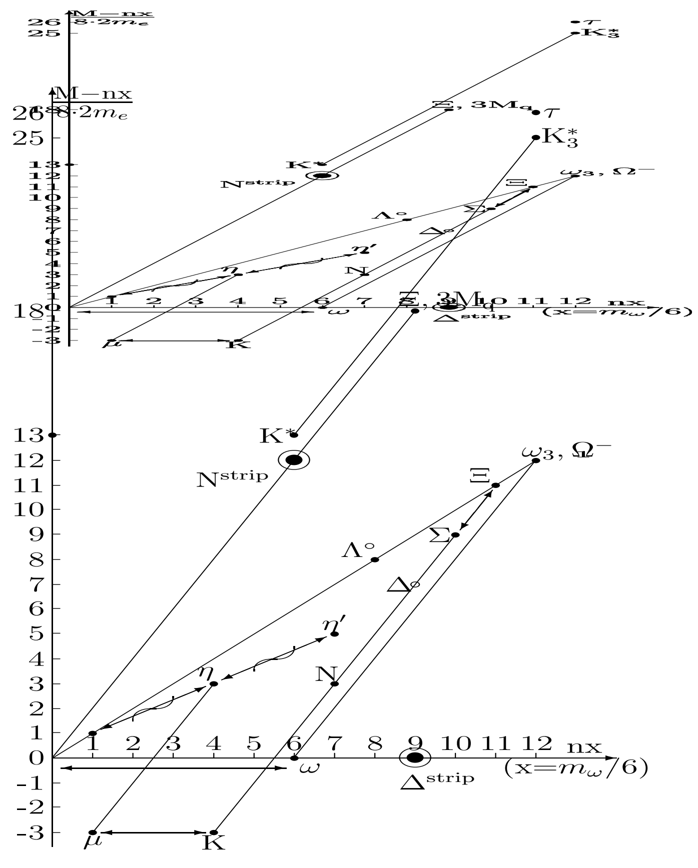

Figure 2. Different mass intervals and hadron/lepton masses shown by the two-dimensional mass-presentation with the horizontal axis in units 16·16m_e close to m_ω/6. Residuals M_i - n(16×16m_e=16δ) are plotted in the vertical direction (y-axis with units of δ =16m_e). Three values corresponding to different estimates of constituent quark masses are shown as lines with different slopes: horizontal line corresponds to the Wick's interval $m_\omega/2=M''_q$ [6,10]; crossed arrows - to M^Δ_q=409 MeV [6,10,29] and parallel lines – to the interval considered by Sternheimer and Kropotkin M_q=441MeV [6,10,11].

The constituent-quark mass arises from a cloud of low-momentum gluons attaching themselves to the current-quark; this is dynamical chiral symmetry breaking: a non-perturbative effect that generates a quark mass from nothing (even at the chiral limit m_q=0, bottom curve in Fig. 1 right [16]).

The pion is simultaneously a Goldstone mode and a bound-state of effectively massive constituents [16]. The quark-parton of QCD acquires a momentum-dependent mass function (Fig.1) that at infrared momentum (p=0) is larger by two-orders-of-magnitude than the current-quark mass (several MeV [3]) due to a heavy cloud of gluons that clothes a low-momentum quark [15,16].

3. Long-range correlations in nuclear binding energies

Stability of differences of binding energies ΔE_B in nuclei differing by α--cluster was noticed in [6]. In Fig. 3 ΔE_B -distributions in $Z \leq 26$ nuclei differing by 2α- and 4α-configuration are shown. The positions of maxima at 73.6MeV=16Δ and 147.3MeV=32Δ are exactly 1:2. For analysis of nuclear binding energies we use here the so-called Adjacent Interval Method (AIM) in which one fix all stable intervals (x) in the ΔE_B spectrum and plot distributions from the fixed binding energies to all other energies ΔE_B^{AIM}. The application of AIM-method allowed additional study of the nuclear dynamics.

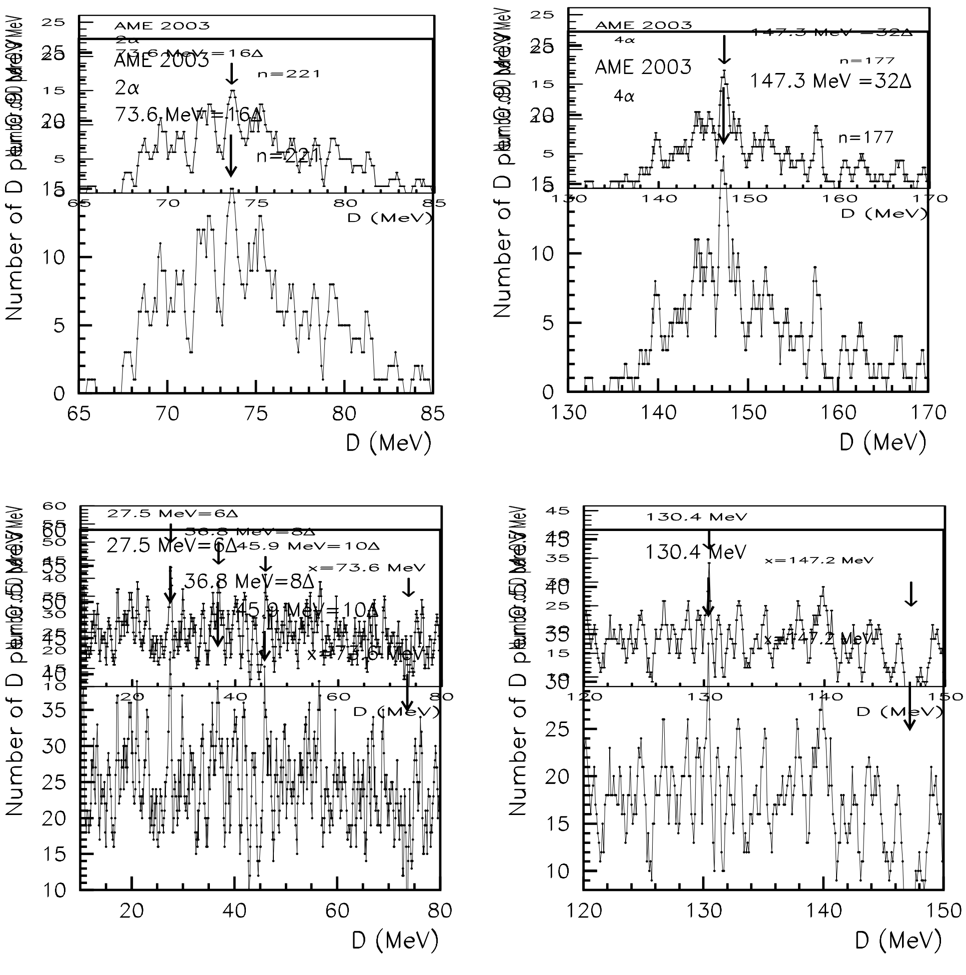

Figure 3. *Top*: ΔE_B-distributions in nuclei $Z \leq 26$ differing by two and four α-clusters: marked are ΔE_B =73.6MeV=16Δ=9δ and 147.2 MeV=32Δ=18δ with Δ=9m_e. *Bottom*: ΔE_B^{AIM}- distributions in all $Z \leq 26$ nuclei of intervals adjacent to fixed with x=73.6 MeV (left, Δ=9m_e) and for x=147.2 MeV.

Using the AIM-method and $x=\Delta E_B$=147.2 MeV=18δ=32Δ in all $Z \le 26$ nuclei we observe maxima at ΔE_B=16Δ=9δ=73.6 MeV and 130.4 MeV=16δ–ε_0/2 (Fig. 3, bottom right). With another $x=\Delta E_B$=73.6 MeV, we observe a periodicity with Δ=4.6 MeV (n=6,8,10, bottom left). The ΔE_B-distribution for all $Z \le 26$ nuclei has maxima near integers n=16 and 17 of δ, while in nuclei differing by 4α (Fig. 3) maximum coincides with 18δ=32Δ. The same stable interval 147.1 MeV=18δ=32Δ was found out in nuclei differing by ΔZ=8, ΔN=10. The ΔE_B-distribution in Z=65-81 nuclei has maxima at 147 MeV =32Δ and 188 MeV=41Δ. Intervals ΔE_B=147.1 and 106.1 MeV=13δ are adjacent to each other [7].

An effective method of a study of nuclear dynamics is the use of a cluster effect: stable ΔE_B= 46.0 MeV (n=10 in units Δ), ΔE_B=50.6 MeV (n=11), ΔE_B=41.4 MeV (n=9) were found in the independent data for heavy nuclei (N=50-82, $N \le 50$, Z=79-81) differing by ^{6}He-cluster. The discussed stable intervals in nuclear binding energies are presented in Table 1 and 2 together with particle masses and different mass intervals. The nuclear nucleon interactions are result of the spilling out of strong QCD interaction between quarks [19]. We consider all intervals as the parameters of the QCD dynamics.

Table 2. Presentation of the parameters of tuning effects in particle masses (upper part) and the tuning effects in nuclear data (ΔE_B and excitations E*) by the expression $(n\cdot 16 m_e(\alpha/2\pi)^x)\cdot m$ with the QED parameter $\alpha=137^{-1}$. One asterisk marks intervals observed earlier in low-energy excitations and in neutron resonances; two asterisks mark intervals found in [18,21]; parameter ε_{np}=340 keV is discussed in [14], numbers of figures correspond to the review [18]; discussed here results are given in the bottom section. Boxed are the values related to $(2/3)m_t=M_H$ with the QED factor $\alpha_Z=129^{-1}$ [7-9].

X	m	n=1	n=13	n=14	n=16	n=17	n=18
-1	1/2				M^{L3} = 58		
GeV	1		M_Z=91.2		$\boxed{M_H = 115}$		
	3/2				M_t=174		
0	1	$16m_e = \delta$	m_μ=105.7		(f_π=131)	$\boxed{m_\pi - m_e}$	147 = ΔM_Δ
MeV	3				$M''_q=m_\rho/2$, $m_\omega/2$	M'_q= 420	M_q = 441
0	1	$2\Delta - \varepsilon_0$	106=ΔE_B		130=ΔE_B	140=ΔE_B	147.2=ΔE_B
MeV	3						441.5=ΔE_B
1	1	9.5=δ′	122*	132**	152**	161**	$\boxed{170 = m_e/3}$
keV	4	39*	492, Fig.16	532, Fig.22		646*, Fig.22	685*,Fig.20
	6		736*		910, Fig.22	965, Fig.25	1022, Fig.16,21
	8	76*	984, Fig.16	1060, Fig.25	1212*	1293*=D_0	1360, Fig. 18
	8		985, Fig.25	1061**		1293*, Fig.25	1366, Fig.25
	12		1476, Fig.16				
2	1	11* = δ′′	143*		176*	187*	198*
eV	2	22*	286*			375*	396*
	4	44*	572*			750*	D
	8					1501*	in resonances
1	3					(481)	512
keV	4					648	
	6					965	This work
	8			1061		1293=D_0	Fig. 6

4. Tuning effect in particle masses

Constituent quark mass estimates $M''_q=m_\rho/2\approx m_\omega/2$, M_q^Δ, $M_q=M_\Xi/3$ and $M_q'=3m_\pi$ [5-9,18] were considered here in line with Nambu suggestion [20] that the analysis of empirical relations in particle masses could be useful for the development of the Standard Modell. It was noticed in 70-ties that there is a double relation between m_e and the Sternheimer/Kropotkin interval $M_q=3\Delta M_\Delta=3\cdot147$MeV= 441 MeV = ΔE_B, namely, the ratio m_e/M_q =1/32·27 = $1.157\cdot10^{-3}$ derived from the above mentioned relations (1) and (4) in particle masses is very close to the QED correction $\alpha/2\pi=1.159\cdot10^{-3}$.

From this observation and the above discussed finding that both accurately known SM-parameters, namely, masses of the muon and Z-boson form a ratio $m_\mu/M_Z=1.159\cdot10^{-3}$ coinciding with $\alpha/2\pi$ (α=1/137) follows that the ratio M_Z/M_q is very close to L=207. Moreover, this ratio L=207 exists between the masses of both vector bosons M_Z=91.188(2)GeV and M_W=80.40(3)GeV and two above discussed estimates of baryon/meson constituent quark masses M_q=441MeV=$m_{\Xi^-}/3=(3/2)(m_\Delta-m_N)$ and $M''_q=m_\rho/2$=775.5(3)MeV/2=387.8(2)MeV: M_Z/441MeV=206.8; and $M_W/(m_\rho/2)$=207.3 [7-9,18]. Such a property of SM-parameters should be considered as an example of an application of Nambu's suggestion. It could reflect the dynamics of Standard Model condensate.

The groupings in nuclear binding energies at 147.2 MeV and 441.5 MeV give independent support for the distinguished character of these QCD parameters. The presence of long-range correlations in particle masses / nuclear intervals (parameters m_e, D_0 etc.) will be considered in a separate analysis.

The involvement of nucleon mass, its excitation, ω -meson and ρ -meson masses in accurate relations is in accordance with the result by Frosch [22,14] who searched for a periodicity in accurately known 47 particle masses and found out the period of $3m_e$ as the most distinguished one. We showed before that a closeness of pion's electromagnetic mass splitting δm_π to $9m_e$ [5,6] was used for introducing a doubled value of pion's β-decay energy as the period $\delta=16m_e$ for the presentation of particle masses.

The mass of the neutron is expressed as $m_n=(6\cdot17 + 13)\delta-m_e$, according to the relation between masses of nucleon, pion and muon noticed by Nambu in 50-ties [20]. This value fits the systematic by Frosch ($n\times3m_e$) and deviate from the accurately known neutron mass by 161.8 keV. Such a shift is equal to 1/8 of nucleon mass splitting $\delta m_N = m_n - m_p$=1293.3 keV and forms with the pion mass the ratio 161 keV/140 MeV=1.16×10^{-3} close to the QED correction 1.159×10^{-3}. All discussed ratios between mass/energy intervals which turned out to be close to QED correction are given in Table 2.

The evolution of the QED parameter α with momentum transfer is presented in Fig.4 (left) for the region from the low-energies ($\alpha\approx1/137$) up to Z-boson mass ($\alpha_Z\approx1/129$), while in Fig.4 (right, from [24,3]) the result of the mass determination for a possible Higgs boson at M_H=115 GeV is shown.

The values presented in Table 2 and situated one under another in different sections X (in each of the vertical columns marked by n) could be expressed by the dimensionless factor $\alpha/2\pi\approx(1/27\cdot32)$.

For example, value ΔE_B=130MeV (close to $m_\omega/6=M''_q/3$ and to f_π=131MeV [27]) is situated under the above-mentioned preliminary value M_H [3,24]. It was noticed that this value is twice the value 58GeV found in L3 LEP experiment by Ting and coworkers [28] and forms relation 2:3 with the mass of the top quark m_t=171.2(21)GeV [3]. The value $m_t/3$=57.1GeV relates to M_q as 129(2) close to 8·16=128.

The relation 1:2:3 between the non-confirmed parameters M_H=115GeV and M^{L3}=58GeV (the LEP experiments) and the known value m_t is given in the upper part of Table 2. It was discussed [8,9] in connection with Wilchek remark that the top-quark mass is "the most reasonable of quark masses" [26]. A connection with the preon models could be considered seriously if these LEP parameters will be confirmed. It should be noticed that the τ-lepton mass m_τ=1777.0(3) MeV [3] coincides with the doubled sum $m_\mu+m_\omega$ of 1776.6(2)MeV. Hence the mass values of all leptons (m_e, m_μ, m_τ) can be expressed as the QED corrections of the SM/NRCQM parameters M_q=441MeV, M_Z and M_H =2/3m_t. In this respect a check/confirmation of the earlier LEP results is urgently needed.

In addition to relations with the QED correction with α=1/137 the empirical ratio between (1/3)$m_t=M_H/2$ ($\approx8\cdot16M_q$) and $m_q=m_\pi/2$ was found to be close to the QED correction for short distances (with $\alpha_Z\approx1/129$, see Fig.4). In Table 2 it corresponds to the stable ratio between the boxed values

$(2/3)m_t=M_H$, pion mass $m_\pi=2m_q$ (the discussed earlier chiral quark mass) and $m_e/3$ [7-9,18]. We see that pion mass takes part in many discussed relations. The estimate of constituent quark mass M'_q=420MeV (or $3m_\pi$) can be obtained from observations: 1) by Nambu - that Λ-hyperon mass is close to 8 m_π [20,6], 2) by Samios [23] - that the first splitting in the decuplet $m_{\Omega^-}-m_\Xi$=137~MeV is close to m_π=140MeV, and 3) the fact that Ω^--hyperon mass is close to 12 m_π [6,14], hence $M_s=4m_\pi$, $M_{q'}\approx3m_\pi$ (see relations in Table I, left). It was marked by Mac Gregor [29] that the radial excitations in the bottomium is close to $4m_\pi$ (Table I), in [3] these excitations are given as sequences (1S, 2S etc.).

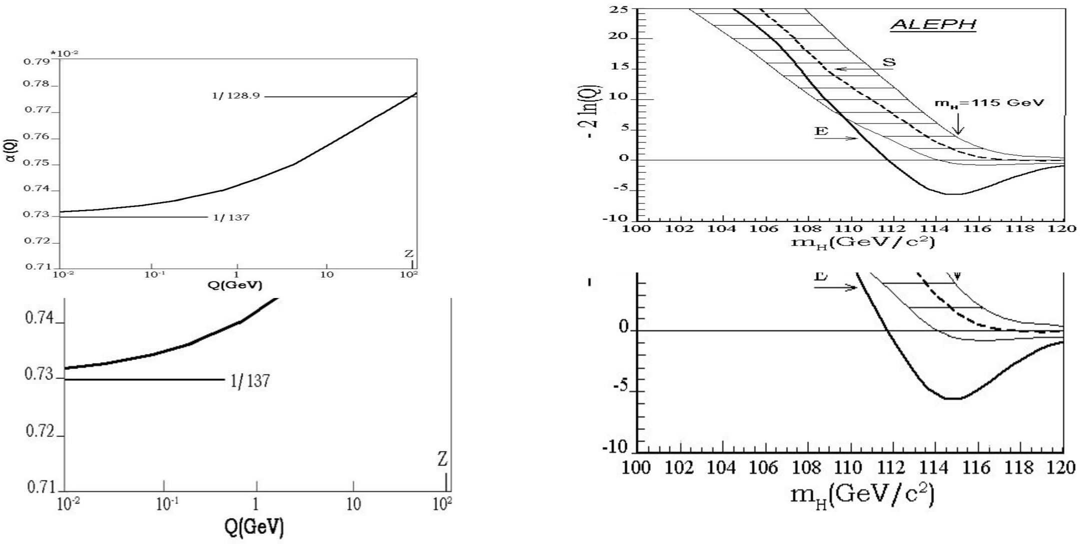

Figure 4. *Left*: Momentum transfer evolution of QED effective electron charge squared. Monotonously rising theoretical curve is confronted with the precise measurements at Z mass at LEP collider [25]. *Right:* ALEPH results with about 3 standard deviation at mass 115GeV; observed (solid line) and expected behaviour of the test statistic (shaded region) are presented and discussed in [3,24].

The radial excitation of the charmonium vector meson is close to four-fold value of the ΔM_Δ, while the mass itself is close to the integer k=21 of it [14] (Table 1, right). It was noticed by Kropotkin [11] that the parameter M_q=441MeV=$3\Delta M_\Delta$ introduced by Sternheimer [10] (discussed earlier) is close to 1/3 of the mass value of the Ξ^--hyperon. It is the result of a compensation of the mass-increase from doubled strangeness by the mass-decrease due to the residual constituent quark interaction. Small additional mass-shift in baryon masses (of the neutron, Σ^o- and Ξ^o-hyperons) was considered in [8,14].

Additional parameter of nucleon structure N^{strip} shown in Fig.2 at 882 MeV=$2M_q$=2×441MeV corresponds to the lattice QCD calculations of the nucleon mass for the limit of pion mass equal to 0. A.Thomas with coworkers [30] and Weise [31] estimated this parameter (884 MeV). After adding of $2\Delta M_\Delta$=294 MeV we can obtain the parameter $M^{strip}{}_\Delta=M^{strip}{}_N+2\Delta M_\Delta=8\Delta M_\Delta=3M''_q=9\cdot16\delta$ (on the x axis).

5. Tuning effect in nuclear excitations

The main task of this work is to show the possible fundamental application of nuclear data analysis. It should be noticed that the dimensionless factor $\alpha/2\pi$ was found to be useful in the analysis of nuclear data performed in ITEP and PNPI since 70-ties [6,14,21]. For example, a stable character of the valence nucleon residual interaction was found in many nuclei in data for nuclear binding energies and excitations. By using the standard method of estimation of (np)-residual interaction parameter ε_{np} from the difference of valence nucleon separation energies in neighbor nuclei values ε_{np} = 340 keV, 680 keV, 1022 keV were found. The ratio (ε_{np}=340keV)/(294 MeV=$2\Delta M_\Delta$)=1.16x10^{-3} is close to $\alpha/2\pi$.

The tuning effect in nuclear excitations consists in the appearance of stable energy intervals D close (or rational) to electromagnetic mass differences of the nucleon $\delta m_N = m_n - m_p$=1293.3 keV [3], the electron D = m_e=511 keV (or D=2m_e=ε_0) and the pion Δ=9m_e. For study of this effect in the data on excitations E* of many nuclei contained in the recent compilations [32] we select data for nuclei situated near the different closed shells. For example, a spin-flip effect in ^{10}B corresponds to D=$E^*(1^+$,T=0)-E*(0^+,T=1)=1021.8(2)keV=2m_e=ε_0 and the first negative parity excitations E*=5110.3 keV=5ε_0 and 6127.2 keV of ^{10}B are close to n×ε_0; the spin-flip effect in another light near-magic nucleus ^{14}N corresponds to E*=2315.3 keV close to 2m_e+δm_N= 2312.8 keV, the 0^+ - excitations in ^{18}Ne at E*=3576(2) keV and 4590(8) keV are close to 7m_e and 9m_e etc.

The grouping in E*-distribution for nuclei with A ≤ 150 at E*=1022(2) keV=ε_0 discussed in [14] corresponds to three-fold values of the stable parameters of the nucleon residual interaction ε_{n2n}=ΔS_n(ΔN=2) in N-odd nuclei and ε_{n2p}=ΔS_n(ΔZ=2) in odd-odd nuclei [14,18]. In excitations of near-magic nuclei the value E^*=340 keV≈ε_0/3 was found in ^{59}Ni, as a stable interval *D*=342 keV in ^{43}Ca bound levels and in neutron resonances of target nuclei ^{40,42}Ca. Nuclei ^{59}Ni, ^{43}Ca and ^{103}Sn (with E*=168.0(1) keV≈ ε_0/6) have three neutrons above a core and the splitting with ΔJ=1 of their ground states are due to the residual interaction of nucleons. The nucleus ^{43}Ca itself has a single-particle splitting E*=2ε_0=2046 keV (7/2$^-$ - 3/2$^-$); D-distributions in ^{42}Ca, ^{38}Ar, ^{92}Zr (two valence nucleons) have maxima at *D*=511 keV= ε_0/2 and 1021 keV= ε_0 [18].

In ^{92}Zr with two valence neutron configuration at Z=40 shell (N=50+2) the maximum at *D*=510(2) keV in spacing distribution was studied by the AIM method. For x=510 keV one can observe D^{AIM}=341 keV which means that intervals 510—341 keV (with the ratio 3:2 between their values) are interconnected [18]. In sum distribution of excitations in light nuclei with Z ≤ 29 both values E*= D_0 and 2D_0 are clearly visible (Figure 5). In the central part of Table 2 some earlier results are presented.

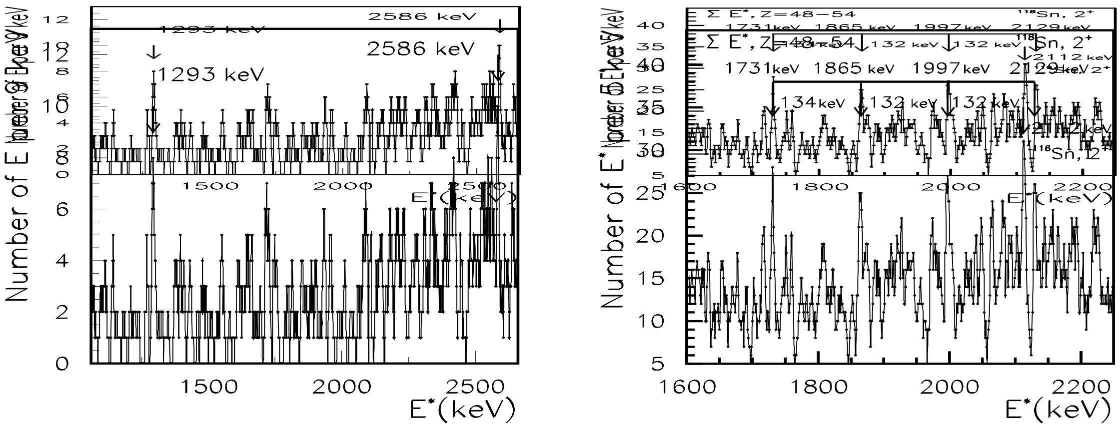

Figure 5. *Left*: Sum distribution of excitations (Σ E*) in all nuclei with Z<29 (averaging interval of ΔE=9 keV), marked by arrows are stable excitations with values D_0 and 2D_0, where D_0=δm_N=1293.3 keV is the nucleon electromagnetic mass splitting. *Right*: Sum distribution of excitations (Σ E*) in all nuclei with Z=48-54 (averaging interval 5 keV); arrows mark periodicity with the parameter of 133 keV (n=13-16) and two-phonon-like excitations in ^{116}Sn, ^{118}Sn [14,18] (phonon 1060keV=8×133keV).

In this work we studied D-distributions in two nuclei ^{97}Pd and ^{98}Pd situated close to the group of nuclei with Z=48-54 (around magic Z=50) where the period 133keV in distribution of excitations was found (Fig.5 right [14,18]). In both nuclei studied the stable interval of the same series and n=8 D=1061keV=8x133keV was found (two top parts of Fig.6). In sum distribution (Fig.6 bottom) besides D=1061keV (4σ deviation) additional stable intervals with values D_0, D_0/2 and 512keV =ε_0/2 are seen.

In ^{97}Pd with the valence neutron N=51 the interval D_0 forms sequence of stable excitations based on the ground state. Obtained values of stable intervals confirm earlier results on parameters of tuning effect and are given in the bottom part of Table 2. Similar results were obtained at other nuclear shells.

We see that nuclear data from the recently collected compilations of atomic masses and energy levels of all nuclei [32] allow to check the tuning effect in excitations and binding energies of nuclei with few-nucleon configuration (close to the magic numbers). Some of parameters of these effects are close to electromagnetic mass splitting of particles (D_0, m_e, Δ). We come to conclusion that the existed nuclear data related to few-nucleon effects provide an indirect check of correlations in particle masses and SM parameters as well as the recent lattice QCD results on the origin of nucleon mass (Fig.1).

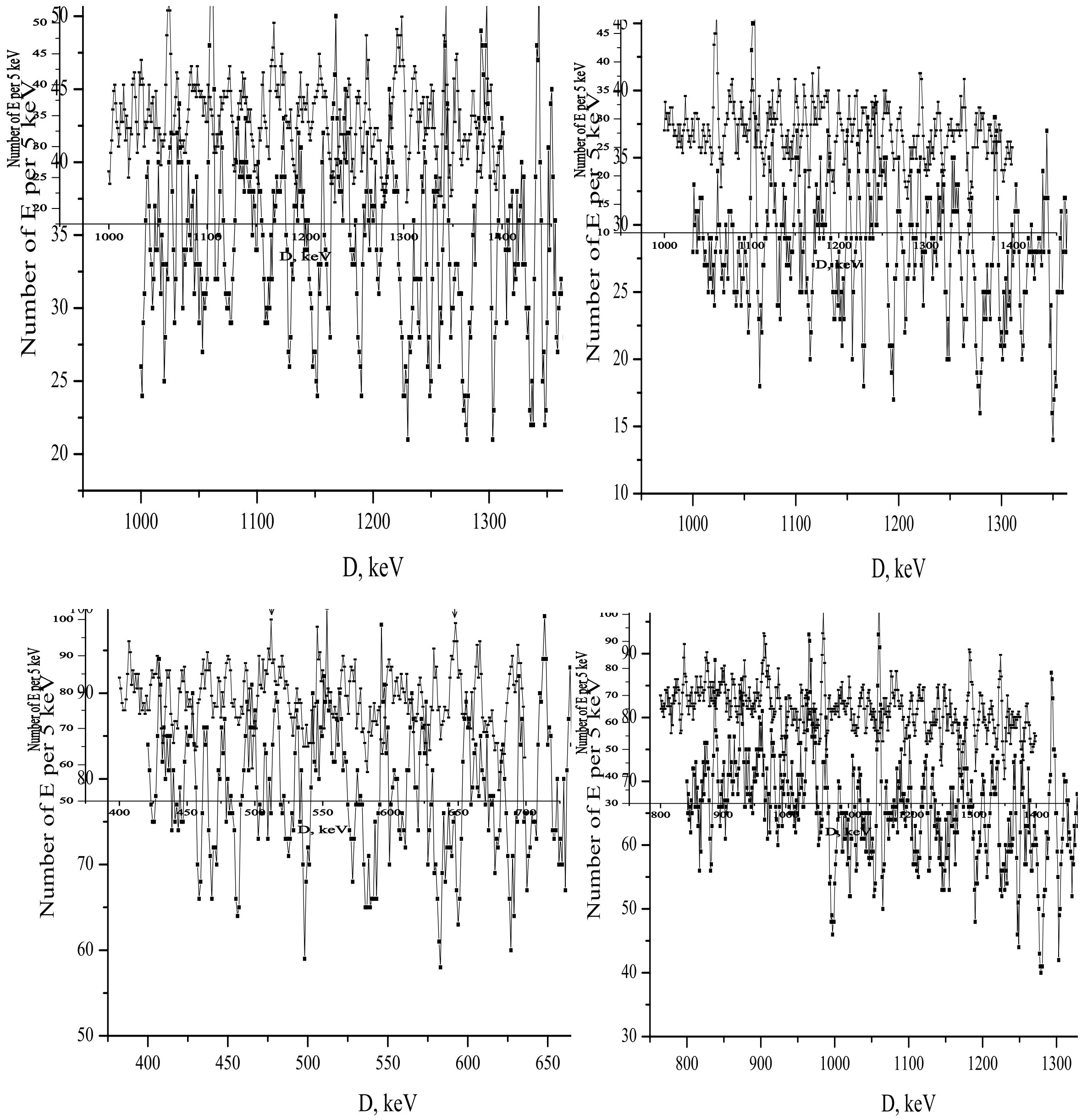

Figure 6. *Top*: Spacing distribution in ^{98}Pd and ^{97}Pd with maxima at D=1061 and 1293 keV =D_0. *Bottom*: Sum spacing distribution of ^{97,98}Pd with maxima at D=512 keV=$\varepsilon_0/2$, 648 keV=$D_0/2$, 1061 keV and 1293 keV=D_0. Interval D_0 forms equidistant excitations in low-lying levels of ^{97}Pd.

6. Conclusions

In this work we considered the recent understanding of the origin of hadronic masses and have found a special role of the QED radiative correction. This correction ($\alpha/2\pi$) was used in the comparison of different relation discussed in the literature. Starting from the suggestions by Devons [33] that nucleon structure effects could be seen in the accurately measured nuclear data and by Nambu [20] that the mass problem in the Standard Model could be very important we have found empirical relations in particle masses which could be useful for SM-development. They include the radiative corrections to the masses of the top quark, lepton and vector boson masses. The need to check the preliminary values M_H and M^{L3} obtained during LEP experiments is evident. The nuclear data support the distinguished character of parameters 147 MeV=ΔM_Δ and 441=3x147 MeV =M_q of NRCQM and corresponding nucleon residual interaction parameters 170 keV and 511=3×170 keV.

Application of the QED correction to large mass/energy values M_q and M_Z gives the observed lepton ratio m_e:δm_π:m_μ=1 : 9: (L=9×23=13×16-1). Here the intermediate term 9m_e is connected with two systematics observed in the known masses: 1) the 3m_e period by Frosch and 2) the δ=16m_e period in the discussed tuning effect. Both periods (3m_e and 16m_e) could be expressed as the QED correction of the 3M_q (mass of three-quark baryon configuration) and the doubled value of the bottom quark mass about 4 GeV [3] (9M_q =3.95 GeV). The tuning effect in particle masses (especially with a possible LEP results) and the results of nuclear data analysis could provide a further SM development.

The author appreciate the help in this work by Z. Soroko and D. Sukhoruchkin.

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