NEW NUCLEAR DATA COMPILATIONS COLLECTED IN PNPI. II

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Abstract

Tuning effect in particle masses which includes masses of leptons and QED radiative correction was analyzed in view of newly obtained mass of the scalar field. A fundamental aspect of the role of nuclear data in the study of the tuning effect is connected with the involvement of constituent quark masses into this tuning effect.

1 Introduction

In this work we continue the study of excitations in different nuclei (including spectra of neutron resonances) which could be connected with the fundamental aspects of nucleon interaction – the one-pion exchange dynamics.

Common hadronic origin of some observed relations in particle mass spectrum can manifest itself in another hadronic objects – in nuclei. It can be observed as a presence of common stable intervals in nuclear binding energies/excitations and in a similarity between parameters which are used to describe such effects in nuclear data and in particle masses. Discussed in the first part of this work [1] an appearance of nuclear mass/energy intervals with values close to mass splittings of the pion, the nucleon and the lepton (m_e) as well as the nucleon Δ excitation ΔM_Δ=147 MeV was considered as indication on the validity of such approach to both hadronic effects.

We extend the above discussed tuning effect in particle masses to the limit of the existed now accuracy in the ratio between masses of nucleons and the electron. Recently published standard data on their masses [2] allows (with some reservations) explaining the empirically observed in nuclear data simultaneous appearance of stable intervals 161 keV=Δ^{TF}=$\delta m_N/8$=1293.345 keV/8 and 170 keV=$\varepsilon_o/6$=$m_e/3$ where δm_N and m_e are mass differences of the nucleon and the electron. From the recommended value of the neutron/electron mass ratio 1838.6836605(11) [2] the shifts of the neutron (δm_n) and of the proton (δm_p) masses from the nearest value 115·16m_e-m_e were determined (δm_N=δm_p-δm_n). The shift in neutron mass is δm_n=161.65(6) keV, the ratio $\delta m_N/\delta m_n$=8(1.0001(1)). It means that shifts of neutron and proton masses account 1/8 and 9/8 parts of the total mass difference δm_N. This unexpected result confirms the fundamental property of the nucleon mass difference as a reflection of the nucleon quark structure with the common parameters from both hadronic effects: 1/8)δm_N=161 keV=δm_n=Δ^{TF} and $\varepsilon_o/6$=$m_e/3$=170 keV [3-7].

It was suggested by Y. Nambu [8] that for further development of the Standard Model empirical relations in particle masses could be used. Recently measured mass of the scalar field M_H=125.54(11) GeV [4,9] and the mass of the vector field M_Z=91.188(2) GeV [10] are in the ratio M_H/M_Z=1.382 close to the ratio between integers 18/13=1.385. The corresponding unity period $M_H/18$=6.974 GeV=δ° will be considered later in a view of the similar relation 18:17:16:13 in the low-mass region [4-7].

It is a well-known fact that the common vector character have all three interactions united in Standard Model representation: $SU(3)_{col} \otimes SU(2)_L \otimes U(1)_Y$ [10]. R. Feynman wrote [11]: "The theories about the rest of physics are very similar to the theory of quantum electrodynamics: they all involve the interaction of spin 1/2 objects (like electrons and quarks) with spin 1 objects (like photons, gluons or W's)... Why are all the theories of physics so similar in their structure?". The combined analysis of particle masses and nuclear data which shows the presence of the common symmetry-motivated tuning effect which could be considered together with the remark by R. Feynman [11] that future "super-duper" model would explain simultaneously vector fields unification and representation of the QED parameters from the α=1/137 to the $\alpha_Z \approx$1/129 [12,13].

A search for empirical relations in masses started in 60-ties when Y.Nambu turned attention to relations between masses of the pion ($m_{\pi^\pm}$), the muon (m_μ) and two baryons (m_Λ, m_N). He found relations m_Λ=8m_π and m_N=6$m_{\pi^\pm}$+m_μ [14]. At the same time it was found [15,16] that mass difference of the pion δm_π=4.5936(5) MeV is very close to 9m_e=4.5990 keV=Δ. Their difference (in recent values) accounts $117(11)\cdot 10^{-5}$ which coincides with the well-known QED radiative correction $\alpha/2\pi = 115.9\cdot 10^{-5}$ to the magnetic moment of the electron. V. Belokurov and D. Shirkov suggested that such small factor could be considered also as a part of the electron mass m_e itself [17].

The value δm_π=4.6 MeV is close to the accepted now values of the d-quark mass m_d=4.8(+0.7-0.5) MeV [10]. Due to uncertainties in masses of down- and bottom-quarks (m_b=4.18±0.03 GeV) a proximity of the ratio $m_d/m_b = 115\cdot 10^{-5}$ to $\alpha/2\pi = 116\cdot 10^{-5}$ was not used as well as still unconfirmed mass-grouping effect at 4 GeV$\approx m_b = \Delta^\circ$ [18]).

Important part of the tuning effect is that lepton ratio m_μ/m_e=L coincides with the integer L=207=13×16-1 after the electron mass is reduced with the factor $\alpha/2\pi$. Accurately known masses of the muon and the vector boson are in the ratio m_μ=105.65 MeV/M_Z= =$115.86\cdot 10^{-5}$ which is close to the QED correction $\alpha/2\pi = 115.9\cdot 10^{-5}$ [4-7,19,20]. From the vector field mass and lepton ratio L=207=13×16-1 one obtains the corresponding unity in this ratio M_Z/L=M_q=440.5 MeV [4]. The value of 16δ°=7.0483 GeV is close to the above derived parameter 6.974 GeV from the scalar field mass (a ratio 1.01). Between the parameters Δ°, δ° and M_q a relation $\delta^\circ = 2\Delta^\circ - 2M_q$ exists.

Besides the lepton ratio L=m_μ/m_e=13×16-1 and a basic empirical fact $\delta m_\pi \approx 9m_e = \Delta$ (it means $2\delta m_\pi$-$2m_e \approx 16m_e = \delta$) there are five ratios close to the integers:
f_π=130.7 MeV/2(δm_π - m_e)=16.01
($m_{\pi^\pm}$ - m_e)/2(δm_π - m_e)=17.03
ΔM_Δ=147 MeV/2(δm_π - m_e)=18.02
(m'_η - m_η)=(m_η - m_π)/2(δm_π - m_e)=50.1
neutron mass (m_n + m_e)/2(δm_π - m_e)=115.007.
The relation $m_n = 6m_\pi + m_\mu$=6×17+13=115 found by Y.Nambu long ago [14] is a result of this discreteness ("tuning effect") in many other particle masses.

Now we show a possible dynamics of the observed tuning effect.

We draw attention to the inclusion of nucleon masses into this "tuning effect" [4-7,16]. These masses are described with a good accuracy (about tens of keV) in the Nonrelativistic Constituent Quark Model (NRCQM) and are considered in calculation by C. Roberts and co-workers [21,22] of the gluon quark-dressing effect based on the QCD (see Fig. 2 in [22]). We will show that this foundation of the tuning effect is very important for understanding the common aspects of the hadronization process in particle masses and nuclear data.

2 Parameters of the Constituent Quark Model

Values of constituent quark masses (around 380-440 MeV) obtained from calculations of the gluon quark-dressing effect with Dyson-Schwinger equation and the lattice-QCD [21,22] are in agreement with the standard estimates of quark masses in Constituent Quark Models where they are directly derived from masses of hadrons with parallel quark spins:
1.) the baryon constituent quark mass which is somewhat larger than the one third of Δ-baryon mass M_q^{Δ}=(m_{Δ}=1233 MeV)/3=410 MeV and
2.) the meson constituent quark mass derived as a half of the ρ-meson mass (two parallel quark-antiquark spins) M_q''=(m_{ρ}=775.5(4) MeV)/2=387.8(2) MeV.

Evolution of baryon constituent quark mass from initial value about M_q=440 MeV (M_d=436 MeV in [24]) and M^{init}=1350 MeV)/3=450 MeV in [25] to the intermediate value 1/3 of Δ-baryon mass $m_{\Delta}/3=M_q^{\Delta}$=410 MeV is due to the interaction between quarks (see left part of Fig. 1 from [25], the intensity of Goldstone Boson Exchange interaction is displayed along the horizontal axis). The nucleon mass in free space and in nuclear medium is described in NRCQM-models as the spin-flip effect between constituent quarks (two states Δ and N at the bottom of the left part of Fig.1 [25], m_{Δ}-m_N=294 MeV=2ΔM_{Λ}).

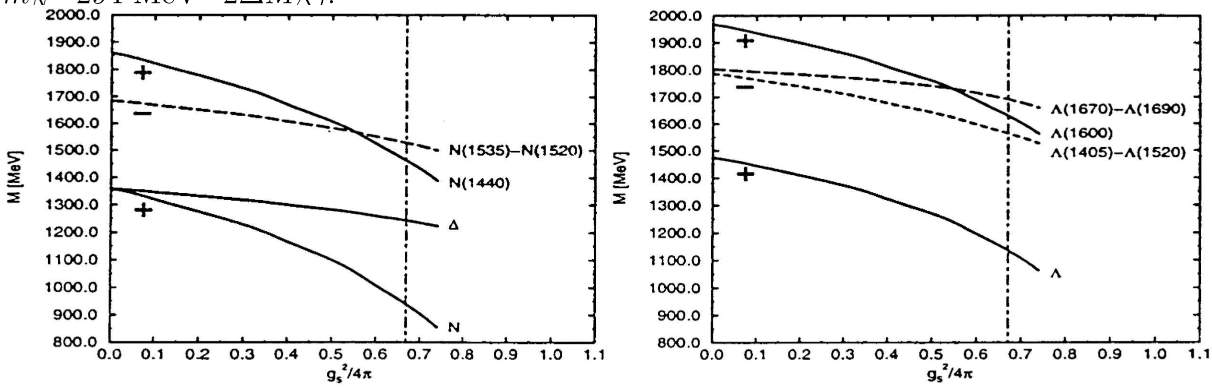

Fig.1. Calculation of nonstrange baryon and Λ-hyperon masses as a function of the interaction strength within Goldstone Boson Exchange Constituent Quark Model; the initial baryon mass 1350 MeV=3×450 MeV=3M_q is marked "+" on the left vertical axis [25].

The starting point of this evolution – the initial baryon mass $3M_q=9\Delta M_{\Delta}$ – and the end – the nucleon mass in the medium (close to 940 MeV-8 MeV=$6f_{\pi}+\Delta M_{\Delta}$) – are shown also in Fig.2 where the parameter $f_{\pi}=16\times16m_e$ serves as the scale for the x-axis [4-7, 16,26,27]). Values M_q and m_N-8 MeV (circled in Fig.2) can be expressed with the two above discussed parameters connected with the pion, namely, the pion parameter $f_{\pi}=16\cdot16m_e$=130.0(7) MeV and ΔM_{Δ}=147 MeV (Δ-excitation per one quark, close to the mass m_s of strange baryon quark). Both intervals are shown in Fig 2 as:
1) horizontal lines corresponding to integers of the parameter f_{π}=130.7 MeV.
2) the nucleon mass (I=1/2) which is situated in a long line from the kaon to the Ω-hyperon. Parallel lines in Fig.2 correspond to the equal or rational intervals. For example, M_q=441 MeV=3ΔM_{Δ}=3×147 MeV is shown in Fig 2 together with the nucleon (the slope 147 MeV). The estimation of the nonstrange baryon mass from the Δ-baryon (three constituent quarks with parallel spin I=3/2) corresponds to three quarks with the mass M_q^{Δ}=410 MeV=m_{Δ}=1232 MeV/3 which coincides with the interval m^T=409 MeV in pseudoscalars (in Fig.2 the Δ-baryon mass is the extension of the line between π-η-η').

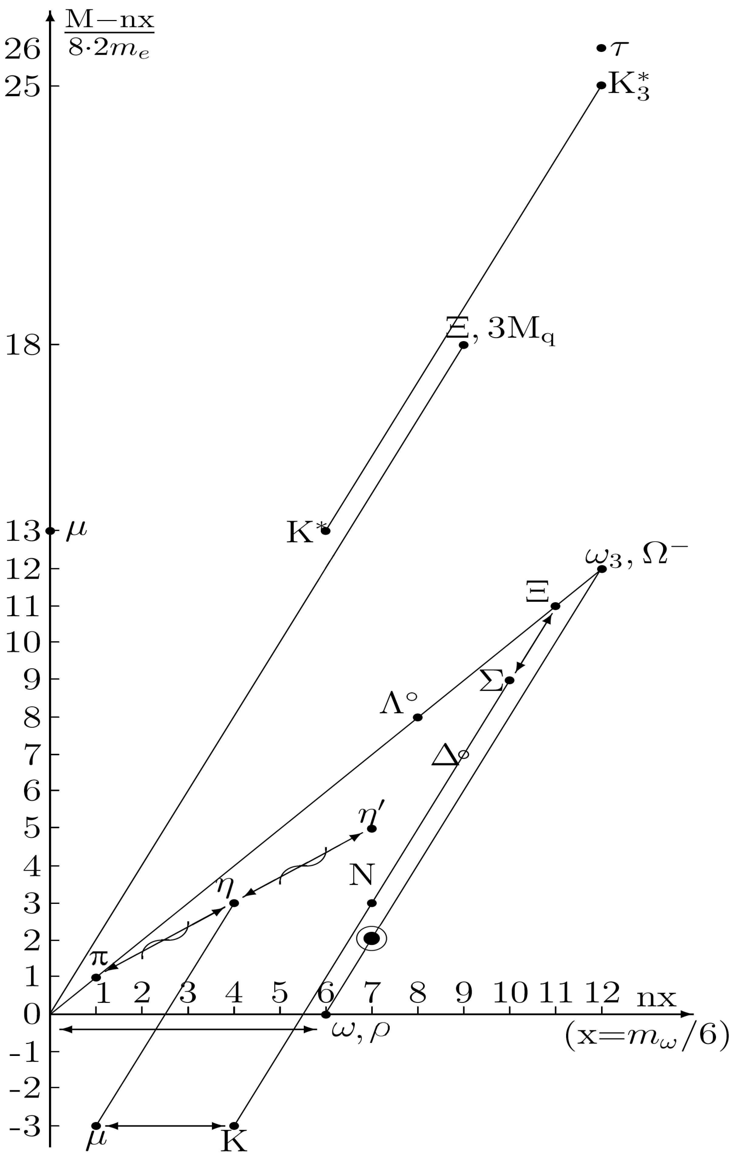

Fig.2. Two-dimensional representation of particle masses [as the period f_π=16·16m_e=130.4 MeV≈ $m_\omega/6$ (somewhat less than pion's mass) along the x-axis and the remainder – in units δ=16m_e. Four different slopes correspond to different mass systematics including noticed by Y.Nambu (line π-Λ-Ξ-Ω) and by T.Takabayashi – equidistance in scalar mesons masses (crossed arrows, π-η-η') are seen in the center, other intervals are considered in the text and [4]. Intervals ω-ω_3 and K^*-K_3^* are close to $2M_q$=2×54δ, τ-lepton mass is 12·16δ+26δ.

The initial mass value M_q=441 MeV in CQM calculations [24,25] is close to the estimate from the mass of double strange octet hyperon m_Ξ=1324 MeV/3=441 MeV in which the quark spin-dependent interaction 147 MeV is compensated with the mass increase of 150 MeV due to the strangeness. Both discussed values of constituent quark masses (M_q, M''_q) equal to the standard estimate in NRCQM (as one third of the real baryon mass and one half of the vector ρ-meson mass) were found [4-7] to be in the constant empirical ratios close to L=207=13·16-1 with vector boson masses (M_Z=91.16 GeV)/441 MeV=206.8 and (M_W=80.40 GeV)/M''_q=207.3. The value from the discreteness in boson masses discussed at the beginning $\delta°/16=(1/16)M_H/18$=125.5 GeV/(18·16)=436 MeV coincides with the value M_d in NRCQM calculations [24] – lines 7-8 in Table 1. Here discussed parameters are given together with the coincidences of the pion parameter f_π=130.7(4) MeV with 16δ and the shift of the ρ-meson mass from the exact value 6·16δ (see comments on 9.2 MeV=2Δ, shifts 5 MeV≈ Δ=4.6 MeV=9m_e are boxed). The NRCQM meson constituent quark mass coincides with M''_q=48δ-Δ within small errors. Similarly the baryon constituent quark mass M_d=436 MeV (in NRCQM [24]) deviates from the three-fold value of the parameter ΔM_Δ derived from Δ-excitation of the neutron (line 5). Value obtained from Z-boson mass and lepton ratio L (440 MeV=M_Z/L) is about 1 MeV less than 3·18δ.

In the bottom part of Table 1 systematic shifts in masses of neutral octet baryons are boxed (the shift 0.5 MeV per increase of the strangeness ΔS=1).

Table 1: Comparison of particle masses with the period 16m$_e$=δ=8176 MeV (shift 9m_e boxed).

No	Particle	m$_i$, MeV	k	m$_i$-k·16m$_e$, MeV	Comments (values in MeV)
1	μ	105.658367(4)	13	-0.6294	-m_e-0.118
2	f_π	130.7(4) [24]	16		≈0
3	$\pi^\pm$	139.5702(4)	17	+0.57624	+m_e+0.065
4	ΔE_B	147.3	18		ΔM_Δ=147, m_s Fig.4 top right
5	$\Delta°$-n	294.2(2)	36		2(ΔM_Δ=147.1)
6	M_q CQM	441	3·18		
7	M_d CQM	436 [22]	3·18-Δ		-5 = -Δ
8	M_H/18·16	436	3·18-Δ		5 = -Δ
9	M_Z/L	440.5	3·18		diff. ≈ -2m_e
10	ΔE_B	441	3·18		Fig.4 bottom right
η'-η,	η-$\pi^\pm$	409	50		≈0
	M_q^Δ CQM	410	50		
	ΔE_B	409	50		Fig.4 bottom left
	ρ	775.49(34)	96	-9.40(34)	-9.20 = -2Δ
	ω	782.65(12)	96	-2.3(1)	diff ≈ -2m_e
	M''_q CQM	m_ρ/2 [16]	48		-4.60 = -Δ
	p	938.2720(1)	115	-1.96660	-m$_e$-(9/8)δm$_N$
	n	939.5654(1)	115	-0.6726(1)	-m$_e$-(1/8)δm$_N$
	$\Sigma°$	1192.64(2)*	146	-1.05(2)	-0.51·2=-1.02
	$\Xi°$	1314.86(20)*	161	-1.47(20)	-0.51·3=-1.53

3 Long-range correlations in nuclear binding energies

An indirect confirmation of the tuning effect in particle masses was obtained in the analysis of differences of nuclear binding energies ΔE_B collected in the file MDF (Mass Differences File) [23,28-30]. Combined analysis of particle masses and nuclear data is based on the understanding of common (discussed above) QCD-based origin of the hadronization.

Observed discreteness in four-proton separation energies was described by the period ε_o=1022 keV=$2m_e$ shown in Fig.3 (top). Stable values of nuclear binding differences ΔE_B=10Δ=45ε_o=46.0 MeV in nuclei with N$\leq$82 and value ΔE_B=40ε_o=41.0 MeV in nuclei with Z=78,82 were found in nuclei differing with ^{6}He configuration (Fig.3 bottom).

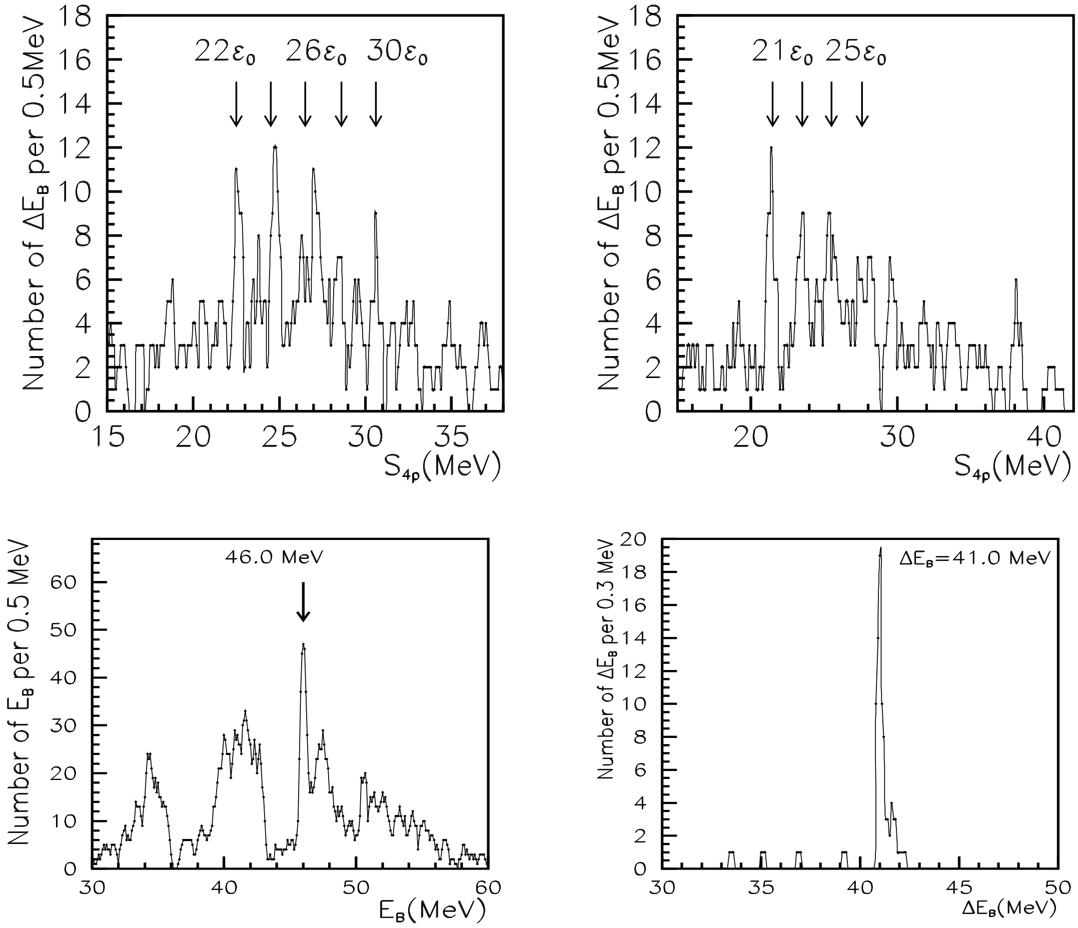

Fig.3 *Top:* ΔE_B-distributions in N-even and N-odd nuclei with Z=50-82 corresponding to four proton separation energies (period ε_o is marked, data from MDF). *Bottom:* ΔE_B-distributions connected with ^{6}He-clusters (ΔN=2ΔZ=4) in nuclei with N$\leq$82 and Z=78,82] (*right*).

Comparison of ΔE_B forming the group at 46 MeV reveals an important aspect in their values: a proximity to integer number of the parameter ε_o=$2m_e$. It is shown in Table 2 (two bottom lines): that such effect – small difference ΔE_B-45ε_o – is absent in the theoretical values calculated within the Finite Range Droplet Model (FRDM) and other models. Such long-range correlations with the parameter ε_o=$2m_e$ were found in nuclear excitations and differences of binding energies of light nuclei (Table 2 right). This effect is appearing in near-magic nuclei ^{36,39}K and do not reproduced in the theory.

Table 2 Comparison of the experimental ΔE_B (keV) and theoretical estimates in magic nuclei (N=82 and N=20) with $10\Delta=45\varepsilon_o$ (^{6}He cluster) and $32\Delta=18\delta=144\varepsilon_o$ (4α in ^{39,36}K).

	Z=55	^{137}Cs		Z=57	^{139}La	Z=58	^{138}Ce	^{140}Ce	Z=19, ^{36}K	^{39}K
N	80	82	78	80	82	78	80	82	17	20
ΔE_B	45946	45970	46018	45927	46024	46087	45997	45996	147152	147160(2)
N$\times\varepsilon_o$		45990			45990			45990	147168	147168
diff.	-44	-20	28	-63	34	97	7	6	-16	-8
FRDM	46620	46340	45950	46820	46970	45960	46850	47160	145950	147450
diff.	630	350	-40	830	980	-30	860	1170	1220	282

Stable differences in total binding energies of light nuclei (Z≤26) differing with two and four α-cluster configurations ($\Delta Z=\Delta N=4$, $\Delta Z=\Delta N=8$) were found at exactly rational values 73.6 MeV=8Δ and 147.2 MeV=16Δ (Fig.4, top). Discussed effect of the proximity ΔE_B to integers of the period $\varepsilon_o=2m_e$ in light nuclei is shown in Table 2, right with the boxed small differences $144\varepsilon_o$-ΔE_B (8 keV in ^{39}K with Z=19,N=20).

In sum distribution of differences of binding energies in all odd-odd and all even-even nuclei maxima were found at 409 MeV and 441.5 MeV=3×147.2 MeV=$3\times144\varepsilon_o=3\times18\delta$. Additional properties of cluster effects were obtained with the application of AIM method.

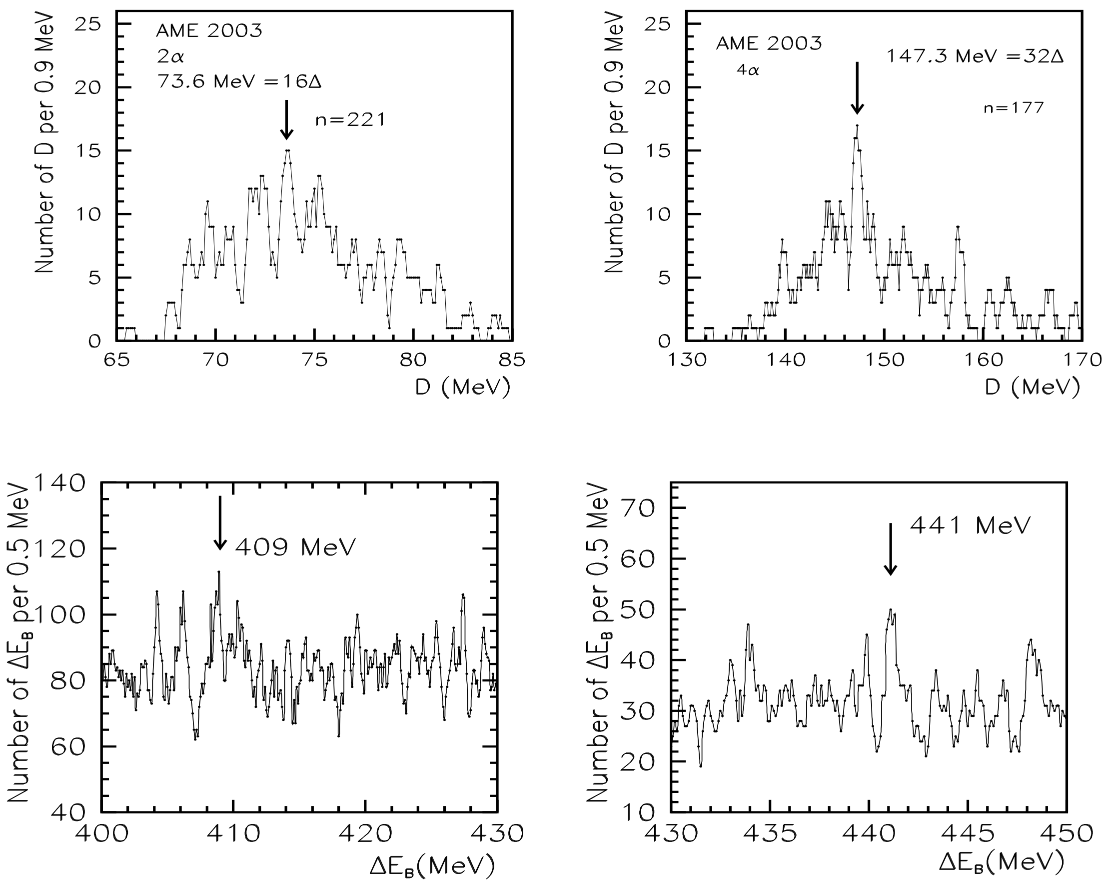

Fig. 4 ΔE_B-distribution of 2α- and 4α-clusters in light nuclei Z≤26 (top) [23]. ΔE_B-distribution in all even-even and all odd-odd nuclei separately (bottom).

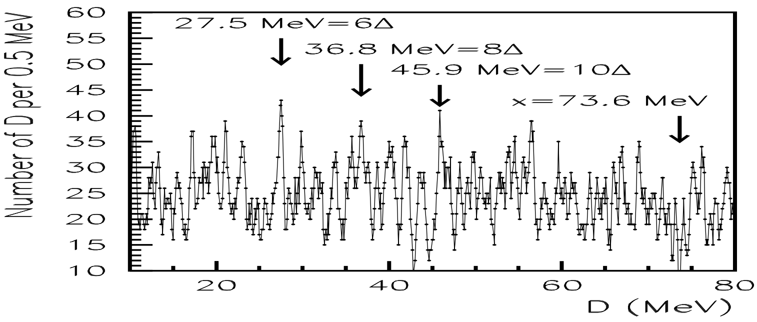

Fig. 5 Distributions in intervals ΔE_B in nuclear binding energies of light nuclei (Z$\leq$ 26) adjacent to stable intervals ΔE_B=73.6 MeV corresponding to the maximum in Fig.4 (top left).

An indirect support of the discussed relations between the particle masses and parameters 18δ=147 MeV and Δ=9m_e in nuclear binding energies was obtained in the correlation analysis (AIM) of cluster effects in ΔE_B with fixating stable intervals ΔE_B=73.6 MeV in all light nuclei. Distribution of interval adjacent to these fixed ΔE_B=16Δ shown in Fig.5 contains clear maxima at D^{AIM}=n$\times\Delta$ (n=6,8,10) corresponding to the discreteness in ΔE_B similar to that in ^{6}He cluster effects in nuclei with N$\leq$82 (Fig. 3 bottom left).

4 Empirical relations with QED radiative correction

Radiative correction of the type $g/2\pi$ is used frequently for the evaluation of effects with different scales [29], for example, in the electron magnetic moment [11] (top line of Table 3). It was used in [32] for an estimation of T-invariance in kaon decay (2-nd line).

In 70-ties an indirect support for this scaling factor $\alpha/2\pi$ was found from a small shift in the muon mass δm=120 keV from 13δ-m_e=23$\times$9m_e. Later the ratio between the muon and vector boson masses was found to be exactly coinciding with $\alpha/2\pi$. This important observation and other discussed relations in particle masses are given in lines 1-3.

The factor $\alpha/2\pi$ was noticed in 70-ties [16,33,34] as ratios between parameters of non-statistical effect $(\varepsilon''=\delta''/8)/(\varepsilon'=\delta'/8)/(\varepsilon_o=2m_e)/2\times440$ MeV=$\alpha/2\pi$ (Table 3, bottom). The parameter 440 MeV in particle masses was found by R.Sternheimer [35] (M_q in text).

In Table 4 values of particle masses and nuclear parameters are expressed as the combination of integer numbers (n, M) and different powers of the discussed scaling factor $\alpha/2\pi$. In such expression $n\cdot16m_e(\alpha/2\pi)^XM$ all parameters $\delta''/\delta'/\delta/\delta^\circ=\alpha/2\pi$ are given at left (column n=1, M=1). Masses of particles ($M_{\rm H}$, M_Z, m_μ, m_π, m_s=ΔM_Δ) and discussed fine structure parameters with n=17,18 are boxed in Table 4. Recently found parameters of nuclear nonstatistical effects [1,27,36] are presented in Table 3 bottom.

The interest in fundamental aspects of nuclear spectroscopy is connected with the role of the one-pion exchange dynamic and results by J.Schiffer [37], T.Otsuka [38,39] and I.Tanihata [40]. Systematic effects in nuclear excitations connected with the tensor nuclear forces which originate mainly from one-pion exchange dynamics were found in antimony isotopes Z=51=50+1 (N=70-82) where stable interaction between $1g_{7/2}$ proton and pairs of neutrons in $1h_{11/2}$ subshell results in the linear trend shown in Fig.6. Stable character of relative positions of single-particle levels (during the filling up the large subshell) was explained by T.Otsuka. It allows determination of the parameter 161 keV=Δ^{TF} which coincides with (1/8) of stable excitations E^*=1293 keV close to nucleon mass difference δm_N in many nuclei including ^{116}Sn (shown in Fig.6 right). In case of stable excitation in near-magic ^{101,103}Sn the observed tensor-force parameter is 170 keV=$m_e/3$. Both parameters (Δ^{TF} and $m_e/3$=170 keV) are manifesting in nuclear data as stable excitations and stable parameters of residual nucleon interactions [22]. Ratios of Δ^{TF} and $m_e/3$=170 keV to the pion mass 140 MeV and ΔM_Δ are close to $\alpha/2\pi$ (Table 3 line 4). Corresponding ratios 161 keV/186 eV and 170 keV/198 eV between intervals of the fine-structure (the period 9.5 keV=δ'=8ε') and the superfine-structure (the period 11 eV=2×5.5 eV=8ε''=δ'') were found in many nuclei (Table 3 line 6, Table 4 bottom).

Table 3. Comparison of the parameter $\alpha/2\pi$ with ratios between mass/energy values.

No	Parameter	Components of the ratio	Value ×10^5
	$\Delta\mu_e/\mu_e$	$=\alpha/2\pi$-0,328 α^2/π^2	115.965
	$\eta_{+-}/2$	2.285(19)×10^{-3}/2 [30]	114(1)
1	$\delta(\delta m_\pi)/9m_e$	[Δ-4593,66(48)keV]/(9m_e=Δ)	116(10)
2	$\delta m_\mu/m_\mu$	[(23x9m_e-m_μ]/m_μ	112.1
3	m_μ/M_Z	m_μ/M_Z=91161(31) MeV	115,90(4)
4	Δ^{TF}/m_π	161 keV/140 MeV	115
5	$\delta m_n/m_\pi$	(nxm_e-m_n)/m_π=161,7(2) keV/m_π	115.86
6	D(187 eV)/161 keV	(375 eV/2=187 eV)/161 keV	117
7	m_s/M_H	147 MeV/126 GeV [3,4]	117
8	$\varepsilon''/\varepsilon'$	1,35(2) eV/1,16(1) keV [15,40,41]	116(3)
	$\varepsilon'/\varepsilon_o$	1,16(1)keV/ε_o=1022 keV [15,40,41]	114(1)
	$\varepsilon_o/2M_q$	$\varepsilon_o/3(m_\Delta$-$m_N)$ [15,40,41]	116.02

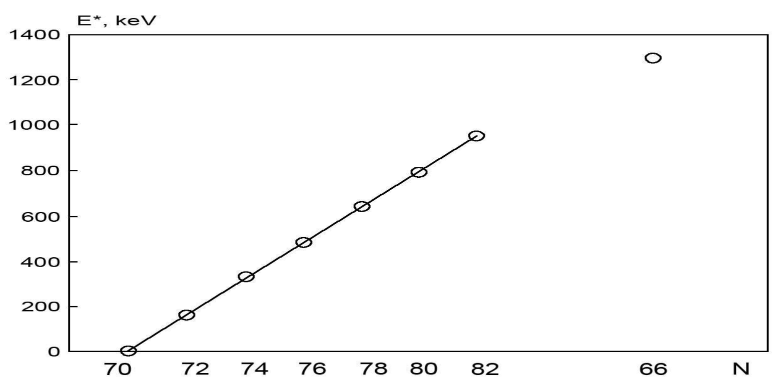

Fig. 6 Linear trend with the slope Δ^{TF}=161 keV in positions of 5/2$^+$ excitations in A-odd antimony isotopes (g.s. J=7/2$^+$) during filling up the large J=11/2- neutron subshell (N=70-82). A carrel at right corresponds to equidistant excitation E^*=1293 keV=δm_N=8Δ^{TF} in ^{116}Sn.

Considered at the beginning the tuning effect in neutron mass from the ratio [2] m_n/m_e=1838.6836605(11) corresponds to the shift 161.650(6) keV (relative to 115δ-m_e) and results δm_N/161.650 keV= =8.00092(2)=8×1.0001(1). It should be pointed out in connection with three aspects:

1) It means a fundamental character of neutron mass m_n, mass difference δm_N and component (1/8)δm_N, it is not occasional that Δ^{TF}=161 keV and 170 keV=$\varepsilon_o/6=m_e/3$ are observed in nuclear data in the regions where one-pion dynamics is expected.

2) There is a very long extension of the discussed long-range correlations in tuning effects with the distinguished character of the electron mass (which is the well-known SM-parameter). In Table 4 a position of the value $m_e/3$=170 keV=3·$(\alpha/2\pi)$147 MeV=$(\alpha_Z)M_q/3$ is seen at right: the value $m_e/3$ is directly represented as the QED correction to the scalar field M_H. Additional shift in neutron mass $m_e=3\times m_e/3$ could correspond to the baryon number (1/3 in each of three quarks forming baryon).

3) The integer lepton ratio L=207 which exists in two different mass scales (in lepton masses m_μ/m_e and between masses of vector bosons and constituent quarks M_Z/M_q, M_W/M''_q) is a fundamental aspect of long-range correlations and reflects the SM-dynamics. As a general theory of all interactions (except gravitation) the Standard Model shows the involvement of the most simplest form of the constituent quark masses. Particle masses reflect still unexplained correlation in gluon quark-dressing effect during mass generation.

Table 4 Presentation of parameters of tuning effects in particle masses and nuclear data (in lines marked X=-1, 0, 1, 2 at left) by the common expression n·16$m_e(\alpha/2\pi)^X$M with QED radiative correction $\alpha/2\pi$ ($\alpha=137^{-1}$). Values m_π-m_e, $m_e/3$, neutron mass shift $k\delta - m_n - m_e$, $\Delta M_\Delta = m_s$ (in baryons) and boson masses are boxed. Stable intervals in nuclear binding energies [26-30] (X=0, M=1), excitations [1,41] (E*, D_{ij}, X=1), neutron resonances [27,36] (X=2) were considered as an indirect confirmation of relations at X=-1 and 0 [4-7]. Unconfirmed mass groupings at M'_H=115 and 58 GeV found with ALEPH, L-3 at CERN [43,44] are at X=-1.

X	M	n = 1	n = 13	n = 16	n = 17	n = 18
-1	3/2			m_t=172.0		
GeV	1	δ°	M_Z=91.2	(M'_H=115)		M_H=126
	1/2	(m_b-M_q)		(M^{L3}=58)		
0	1	16$m_e=\delta$	m_μ=106	f_π=130.7	m_π-m_e	m_s, ΔM_Δ=147
MeV	3			M"$_q$=m_ρ/2	NRCQM	M_q=441=ΔE_B
1	1	9.5=δ'			$k\delta$-m_n-m_e=161.65(6)	170 = m_e/3
keV	1		123	152	Δ^{TF}=161	170 (Sn)
	2				322 (^{33}S)	
	3				484 (E^*)	512 (Co, Pd)
	4		493 (^{18}F)		648 (Pd)	681 (Mg, Co)
	8		986 (^{33}S)	1212	1293 (E^*), 1288 (^{18}F)	1360 (Te)
	16		1968 (^{33}S)		2594 (^{24}Na) 2577 (^{18}F)	
2	1	11=δ''	143	176	186 (^{146}Nd, ^{149}Nd)	neutron
eV	4		570 (Sb,Th)		749 (Br,Sb) 1500 (Pd,Hf)	resonances

5 Lepton ratio repetition

All discussed aspects of the tuning effect are connected with the properties of fermions (leptons, constituent quarks, nucleons etc.). The interpretation of main parameters of the tuning effect – periods δ=16m_e and $\delta°$=16$_q$, scaling factors, repetitions of the lepton ratio was made [4] along the comparison with the quantum mechanics of the fermions. The structure of usual fermion systems (electron in atoms, nucleons in nuclei) is based on the repetition of the principal quantum numbers. Two above discussed periods δ=16m_e and $\delta°$=16M_q which are in the ratio $\alpha/2\pi$ are shown at the top left corner of Table 4 (n=1, X=1,2). They are determined from:
1) difference between the charge splittings of the pion (quark-antiquark system) and m_e,
2) difference between $\Delta°$=m_b=4 GeV and quark mass M_q=0.44 GeV, they both have a similar representation with units $m_e/3$=170 keV and ΔM_Δ,m_s=147 MeV:
1) δm_π=Δ=9m_e=3×($m_e/3$+8$m_e/3$)=3$m_e/3$(1+8), where δm_π=3$m_e/3$(1+8) is the initial cluster-shell block of currents within the pion , and
2) $\Delta°$=9M_q=3×(ΔM_Δ+8ΔM_Δ)=3ΔM_Δ(1+8) – the main initial block of currents within the scalar field. Factor (1+8) in both expressions could correspond to an appearance of new principal quantum number. Resulted observed blocks of currents (differences between the initial blocks and units $m_e/3$ or ΔM_Δ) are involved in a possible explanation of the lepton ratio L repetition proposed in [4].

It is shown in Table 5 [4] that L-ratio exists in two different mass scales (differing with the common scaling factor). The involvement of the constituent quark masses (heavy fermions) is the main suggestion for this empirical approach. Numbers of fermions in the central field given in Table 4 could be meaningful if the values M_q, M''_q obtained in such unusually direct method of the constituent quark mass estimation would be confirmed with further analysis of the QCD-based gluon quark-dressing effect.

Table 5 Comparison of ratios between masses m_μ/M_Z, $f_\pi/(2/3)m_t$, $\Delta M_H/M_H$ and $\alpha/2\pi$ with numbers of fermions in the central field. Boxed are the lepton ratio L and comments about a possible role of the hole configuration in 1p shell.

	Number of fermions	N = 1	16	16·13 – 1	16·16	16·18
1	Particle/param.	$m_e/\ M_q$	$\delta/\delta°$	m_μ/M_Z	$f_\pi/(2/3)M'_{\rm H}$	$\Delta M_\Delta/M_{\rm H}$
2	Ratio	116·10^{-5}		116·10^{-5}	116·10^{-5}	116·10^{-5}
3	Number of blocks		(1)	12+1	16	18
4	States	$1s^4_{1/2}$		$1s^4_{1/2}$, $1p^8_{3/2}$, $1p_{1/2}$	$1s^4_{1/2}$, $1p^8_{3/2,1/2}$	
5	Comments			hole in 1p shell	filled shells	

6 Conclusions

Starting from the empirical relations in recent data on particle masses (tuning effect [3-7]) we consider the discreteness in parameters of the Standard Model as a reflection of hidden fermion symmetry based on the QCD and the quantum mechanics. Data collected in PNPI in three compilations MDF [28], CRF [41] and NRF [36] were used for a check of the fundamental hadronic parameters common in the QCD and nuclear physics.

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