TUNING EFFECT IN NUCLEAR AND NEUTRON RESONANCE DATA

S.I. Sukhoruchkin , Z.N. Soroko, D.S. Sukhoruchkin

B.P. Konstantinov Petersburg Nuclear Physics Institute 188300 Gatchina

1. Introduction

Neutron resonance position ($E'_{\rm n}$, after the recoil correction) is the difference between the excitation energy of the compound nucleus (E^*) and neutron separation energy (S_n, difference of total binding energies of neighbour nuclei). Grouping effect in positions of resonances of many different nuclei observed by several authors (M. Ohkubo, K. Ideno and others [1-3]) indicated on a presence of nonstatistical effects. An example of correlations in position of strong neutron resonances of near-magic ^{140}Ce is given in Table 1 (left). The exact 4:9 relation in positions of resonances and maxima in spacing distribution with the same stable interval (right) were supported with the same intervals in low-lying levels of neighbor ^{143}Ce (center). In neighbour isotopes with the same magic N=82 strong resonances were found at the same energy 9.5 keV and at (1/4) part of it (1188 eV=ε', bottom line, the parameter was introduced in [4]). Grouping effect in positions of resonances at 19 keV=2×9.5 keV=16ε' confirmed the universal character of these effects named the "fine structure in nuclear excitations" considered in 70-ties during the analysis of data on proton and neutron resonances. The observed system of stable intervals (from ε' up to 85 keV=8·9ε') were used as reference points (main parameters ε' and $8\varepsilon' = \delta'$).

Table 1. E'_n of strong resonances in N=83 nuclei, E^*(^{143}Ce) and spacing in ^{141}Ce.

Nucl.	^{141}Ce		^{142}Pr	^{140}La	^{143}Ce	J^π_o=3/2$^-$	^{141}Ce		
J^π_i	1/2$^+$	1/2$^+$	(5/2$^-$)	3$^+$	7/2$^-$	5/2$^-$			
Γ^o_n,meV	660*	3060*	160	54	E^*	E^*	D	D	D
E_n	9.573	21.570	9.598	1.179			21.7	43.1	86.2
E^*,E'_n	$\boxed{9.505}$	21.418	$\boxed{9.530}$	1.170	18.9	42.3			
m($8\varepsilon'$)	1	9/4	1	1/8	2	9/2	9/4	9/2	9
m×$8\varepsilon'$	$\boxed{9.504}$	21.384	$\boxed{9.504}$	1.188	$\boxed{19.0}$	42.77	21.4	42.5	85

Stable character of the first excitations of magic ^{101,103,133}Sn close to 18δ'=170 keV (or rational to it, Table 2) corresponds to the tensor force manifestation. This effect exists in other nuclei with N=51 (^{85}Se, ^{98}Ag, Fig.1 top, Table 2, center). Rational relations were found also with intervals 150 keV=16δ' and 267 keV=28δ' (Fig. 1, bottom). Stable intervals/periods 85 keV=9δ in light nuclei are represented in Table 3.

Table 2. Excitations (in keV) in nuclei with Z=50,34,47, close to integers of the period 18δ'=170 keV=m_e/3=ε_o/6, Δ^{TF}=17δ'=161 keV=δm_N/8 and D in ^{85}Se.

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$^+$
18δ'	170	170	851	1362	170	340	511	(9/8)δm_N	170	511	δm_N	δm_N

2. Fine structure in nuclear excitations

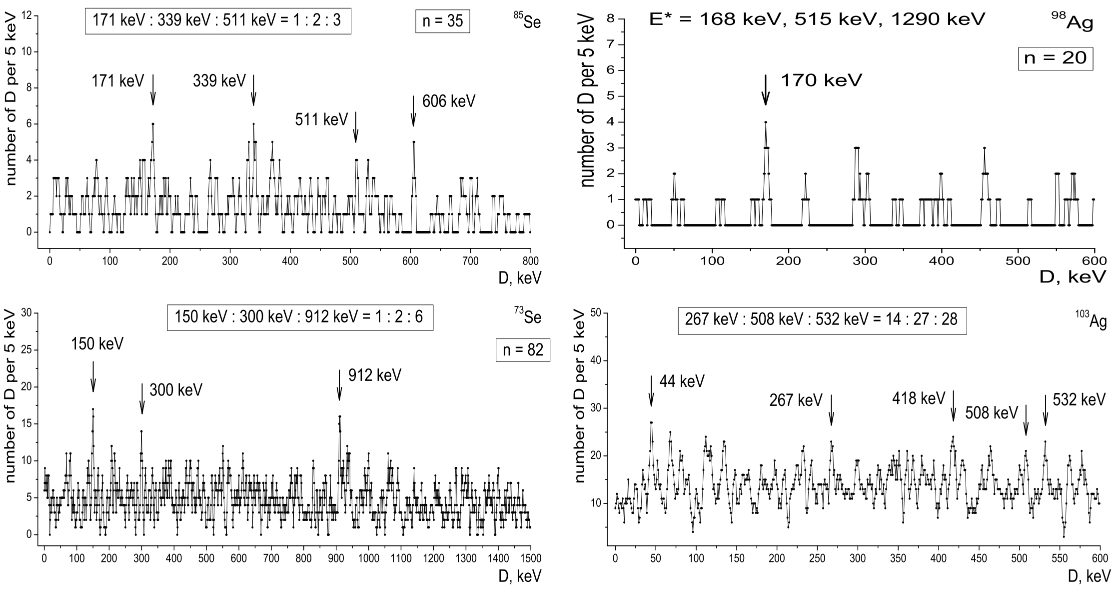

Fig. 1. *Top:* D-distribution in ^{85}Se and ^{98}Ag (both N=51) with maxima at D=n(170 keV=18δ'). *Bottom:* D-distribution in ^{73}Se and ^{103}Ag with maxima at D=150 keV=16δ' and 267 keV=2·14δ'.

Table 3. Comparison of E^* in low-lying levels of Z=26-29 nuclei (with large spectroscopic factors S_N) with integer numbers of $\varepsilon_o/12$=85 keV.

^AZ	^{55}Fe			^{55}Co T=$\frac{3}{2}$			^{57}Ni			^{59}Ni		^{58}Cu T=1			^{55}Co
E^*	0	411	931	4721	4748	5743	0	769	1113	0	339	203	1051	1652	84
$2J^\pi$	3^-	1^-	5^-	3^-	3^-	5^-	3^-	5^-	1^-	3^-	5^-	0^+	(1^+)	2^+	D
S_N	0.7	0.6	0.7	0.45	0.37	1.2	0.9	0.5	0.12	3.3	4.1				
diff				1022	965								848	1449	
n($\frac{\varepsilon_o}{12}$)		425	935	1022				765	1107		340		850	1445	85
n		5	11	12				9	13		2		10	17	1

^AZ	^{54}Co T=1			^{52}Fe			^{57}Cu			^{68}Cu		^{65}Cu			^{65}Cu
E^*	0	937	1146	0	849	2384	0	1028	1106	0	84.6	0	771	1116	85
$2J^\pi$	0^+	1^+	2^+	0^+	2^+	4^+	3^-	5^-	1^-	1^+	(2^+)	3^-	5^-	1^-	D
S_N				2.2	1.5	1.1									
n($\frac{\varepsilon_o}{12}$)		935	1147		850	2384		1022	1107		85		765	1107	85
n		11	17		10	28		12	13		1		9	13	1

New data on light nuclei with Z,N=20,28 allowed to study parameters of fine structure due to few-nucleon effects. Linear dependence of excitation energies upon the number of valence nucleons was earlier found in nuclei with N=21,22 (Table 4). Number of pairs of protons in $1d_{3/2}$ subshell (Z=14-20) in nuclei ^{41}Ca,^{37,38}S is presented in the first line of Table 4. Number of neutrons in the $1f_{7/2)}$ subshell (Z=20-28) is given in the second line. Excitations in these nuclei (double boxed) are rational to each other and are in linear trend upon $\Delta Z, \Delta N$ with the parameter equal to a half of nucleon mass splitting 646 keV.

Table 4. *Top:* Linear trend in excitation energies (in keV) of nuclei with N=21,22 (ΔN=1,2 over N=20). Systematically appearing values $\approx$1293 keV and 322 keV rational with n=8 and 2 to the parameter of the tensor forces (see text) are boxed.

(Z-14)/2	$\boxed{3}$		2	$\boxed{1}$	$\boxed{1}$	1	1	0	0
N				$\boxed{\Delta\ N=1}$	$\boxed{\Delta N=2}$		$\Delta N=7$		
^AZ	^{41}Ca		^{39}Ar	^{37}S	^{38}S	^{33}S	^{43}S	^{32}Si	^{35}Si
E^*	0.0	$\boxed{\boxed{1943}}$	1267	$\boxed{\boxed{646.2}}$	$\boxed{\boxed{1292}}$	322	$\boxed{\boxed{320.7}}$	1942	973.9
$2J^\pi$	7^-	3^-	3^-	3^-	2^+	D	7^-	2^+	(3^+)
$n\frac{\delta m_N}{8}$	0.0	1941	1293	646	1293	322	322	1941	971
n		12		4	8	2	2	8	6
^AZ	^{33}Mg		^{41}K		^{47}Sc	^{47}V	^{50}V	^{51}V	^{55}V
E^*	159	484	980.4	$\boxed{1293.6}$	807.9	$\boxed{1294.9}$	$\boxed{320.2}$	$\boxed{320.1}$	$\boxed{323.3}$
$2J^\pi_o$	3^-		3^+		2^+	3^-	6^+	7^-	(7^-)
$2J^\pi$	(7^-)	(3^-)	4^+	7^-	3^-	11^-	4^+	5^-	(5^-)
$n\frac{\delta m_N}{8}$	161	483	971	1293	808	1293	322	322	322
n	1	3	6	8	5	8	2	2	2

Table 5. *Left:* New data (marked with asterisk *) on excitation (in keV) of ^{53}Ni, ^{53}Mn and ^{53}Co with three holes in magic ^{56}Ni are compared with integer values of the tensor force parameter 161 keV=Δ^{TF}=$\delta m_N/8$, determined in data for nuclei with Z=50,51 and N=21,22. Excitations in Ni,Mg,Co and Cu close to integers of 161 keV=320 keV/2=$\delta m_N/8$ are boxed.

^AZ	^{53}Ni $2J_o$=7-			^{58}Ni	^{59}Ni	^{61}Ni	^{63}Ni		
E^*	$\boxed{\boxed{320(3)}}$	$\boxed{1292^*}$	$\boxed{1456^*}$	$\boxed{1454.2}$	$\boxed{\boxed{339.4}}$	$\boxed{1454.8}$	87.1	$\boxed{1289.1}$	$\boxed{1451}$
$2J^\pi$	(5^-)	(3^-)	(11^-)	2^+	3^-–5^-	7^-	1^-–5^-	9^+	(5,7,9)
$n\frac{\delta m_N}{8}$	322	1293	1454	1454	322	1454		1293	1454
n	2	8	9	9	2	9		8	9
^AZ	^{53}Mn					^{55}Mn			
E^*	378	$\boxed{1289.9)}$	$\boxed{1441.3}$	2563.1	2573.1	$\boxed{1289.1}$	$\boxed{1292.1}$	$\boxed{1293.0}$	2582
$2J^\pi$	5^-	3^-	(11^-)	13^-	7^-	5^-–11^+	11^-	(1^-)	
$n\frac{\delta m_N}{8}$	322	1293	1454	2586	2586	1293	1283	1293	2586
n	2	8	9	16	16	8	8	8	16
^AZ	^{53}Co	^{59}Co				^{69}Cu	^{71}Cu		^{73}Cu
E^*	$\boxed{\boxed{646.2^*}}$	$\boxed{1291.6)}$	$\boxed{1459}$	$\boxed{2581.7}$	2585.8	$\boxed{1297.9}$	$\boxed{1453.3}$	2576(3)	$\boxed{1298.0}$
$2J^\pi$	7^-	3^-	11^-	3^--7^-	7^-	3^-–$1,3^-$	3^-–9^-	(13^-)	$(3^-,7^-)$
$n\frac{\delta m_N}{8}$	647	1293	1454	2586	2586	1293	1454	2586	1293
n	4	8	9	16	16	8	9	16	8

Values in Tables 4-5 are rational with the value 321 keV, which is the effect of the residual interaction of a neutron hole in the same shell (ΔN=7) and a pair of protons in $1d_{3/2}$ subshell (^{43}S, boxed). Values of excitation energies presented in the Table 4 (top): 1942 keV:1292 keV:646 keV:321 keV=12:8:4:2 are given in the units of the tensor force parameter 161 keV =17δ=Δ^{TF}=$\delta m_N/8$, derived from data for Z=50,51 nuclei (Table 6).

In Table 5 new data on excitations of ^{53}Ni, ^{53}Mn and ^{53}Co (three nucleon holes in magic ^{56}Ni) are presented including the newly measured values [5,6] still not included in files ENSDF and CRF [7]. Excitations are compared with the parameter of tensor forces 161 $=\Delta^{TF}=\delta m_N/8$ confirmed in nuclei with N=21,22 (Table 4). Double boxed are:
1) rational to each other values of excitation in ^{59}Co ^{53}Ni (at left, ratio 646/320=2.02) which correspond to the residual interaction of pair of neutrons with the hole in the neutron or proton shells, and
2) the interval from the residual interaction between the valence neutrons in ^{61}Ni and analogous interval from three neutron holes interaction in ^{53}Ni. A ratio between them 339 keV/320 keV=1.06 is close to the ratio 18/17=1.06. They correspond to the doubled values of the fine structure parameters (n=18, 17, δ'=9.5 keV). Many other excitations in Ni, Mg, Co, Cu were found to be close to integers of 161 keV=320 keV/2=$\delta m_N/8$.

A check of the universal character of the fine structure (relation 1:8=δm_n:δ_N=161.7 keV:1293.3 keV) was performed with the analysis of all existed spectroscopic information for the near-magic nuclei with Z=27,28 and Z=49-52. We come to the conclusion that the fine structure in masses of free nucleons (downwards mass shifts 161 keV=$\delta m_N/8$ and 511 keV=3·170 keV) is reproduced in nuclear data for light and near-magic nuclei [11]. The value of the common small fine structure parameter of 9.505 /8 determined from the integer relations 1:8:18 in positions of levels of nuclei with magic N=82 (Table 5) is close to the parameter 1.2 =ε', found earlier [4]. Relation between the observed mass splitting of particles and the parameter δ', namely, $\delta m_N/(8{\cdot}17)$=9.509 keV and $m_e/(3{\cdot}18)$=9.463 keV show that there is really a proximity of the first value to the value 9.505 keV derived from relations between the positions of neutron resonances in nuclei around the ^{141}Ce.

J. Shiffer, T. Otzuka and I. Tanihata [8-10] noticed a possibility to study a role of one-meson exchange dynamics (nuclear tensor forces) within the spectroscopy of nuclei with Z, N=51, where nucleons are situated at the $1g_{7/2}$ and the $2d_{5/2}$ subshells (over a filled large $1g_{9/2}$ subshell). In the antimony isotopes (Z=51) during the filing in large neutron subshell $1h_{11/2}$ (N=70-82) the stable character of tensor forces was found from an observation of linear trend in excitations of the levels with $7/2^+$ (upon the number of neutron pairs, N=70-82). In Table 6 (left) these energies are compared with integer numbers n of the tensor force parameter Δ^{TF}=161 keV. Small deviation of E^* values at n=1 and n=4 from the constant value of the parameter (boxed) is supported with the stable character of similar excitations in neighbour nuclei as it can be seen in maxima at 161 keV, 483 keV and 644 keV in sum E^*-distribution in all Z-odd nuclei with Z=49,51,53,57 (Fig.2 bottom). Obtained parameter of the linear dependence nΔ^{TF} is in agreement with the equidistancy in excitations (0^+-2_1^+-1^+, 1292-1294 keV $\approx \delta m_N$) of the neighbour Z-magic nucleus ^{116}Sn (Table 6, right). Stable character of the interval 161 keV is seen from the maximum in the sum D-distribution in ^{122,124}Sb (close to ^{123}Sb with the first excitation of 160.3 keV, Table 6). Discussed stable nuclear intervals are given in Table 7 (bottom) and in Fig. 5-8 in [15].

Recently F. Wilczek noticed [12] that progress in QED and QCD-lattice calculations of nucleon mass differences δm_N=1293 keV "encourages us to predict a future in which nuclear physics reaches the level of precision and versatility that atomic physics has already achieved ... and entertain dreams of refined nuclear chemistry, enabling ... dense energy storage and ultrahigh-energy lasers." The same value δm_N was earlier considered in [4] and confirmed in the recent analysis of nuclear binding energies and nuclear excitations of the broad scope of nuclei. There exists a discreteness in mass/energy intervals coinciding or rationally connected with the δm_N=1293 keV and the lepton mass m_e=511 keV. For example, periods $\delta m_N/8$=161 keV and $m_e/3$=171 keV were observed in excitations of near-magic nuclei ^{odd}Sb (Z=51, numbers of the period n=1,2,3,4,5,6) and ^{101,133}Sn (Z=50, N=51,83, n=1,5,8). In neighbour $^{116-118}$Sn and ^{113}In phonon-like excitations with values close to δm_N and $2m_e$=ε_o were found in the first excitations, as well as in many stable intervals D=511 keV, 1533 keV and 2045 keV (m_e, $3m_e$, $4m_e$) – in all 183 levels of ^{113}In. Similar grouping effects were found in spacing of all excitations of neighbour ^{116}Te [11].

After the confirmation of fine structure parameters in nuclear excitations similar to that found in CODATA evaluation [24] we return to the problem of the theoretical interpretation of the period $16m_e = \delta = 2(\Delta - m_e)$ in CODATA relation considered in [13-23]. New interpretation of mass presentation of the third lepton (Table 8) could be considered as another step in the development of "new physics" in parameters of the Standard Model.

Table 6. Comparison of excitations E^* (in keV) in $Z = 51$ -odd nuclei with integer numbers of tensor force parameter Δ^{TF}=161 keV=(δm_N=1293 keV)/8 [7].

^{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	$\boxed{\boxed{160.3}}$	$\boxed{332.1}$	$\boxed{491.2}$	$\boxed{645.2}$	$\boxed{798.4}$	$\boxed{962.0}$	644	1294	1292
E^*-$\frac{\delta m_N}{8}$	$\boxed{-1}$	-9	+7	$\boxed{-1}$	-10	-7	-2	1	-1
n$\frac{\delta m_N}{8}$	161	323	484	646	808	969	646	1293	1293
E^*, Fig.2	160		483	644					

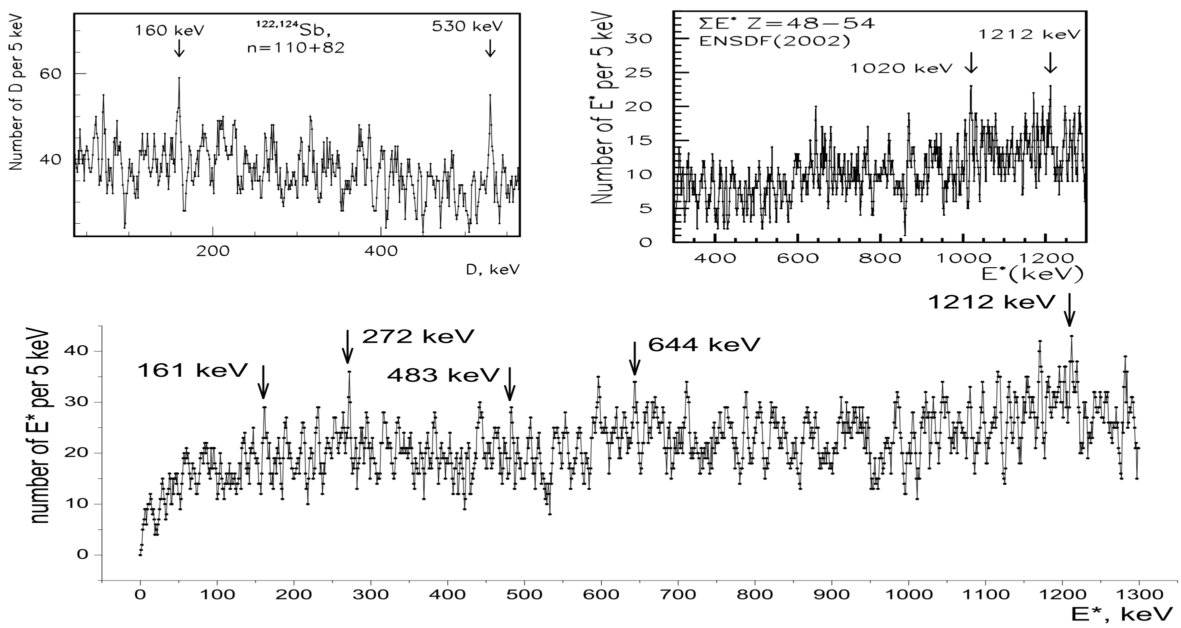

Fig. 2. *Top left*: Sum distribution of spacing in levels of ^{122,124}Sb (the beginning of the subshell). Maxima are at 160 keV=Δ^{TF}=$17\delta'$ and 530 keV=$4\cdot 14\delta'$.
Right and bottom: Sum distribution of level energies E^* in nuclei with Z=48-54 (maximum at ε_o) and in Z-odd nuclei with Z=49-51-53-57 (maxima at 161-483-644 keV=n$\cdot 17\delta'$=nΔ^{TF}) as well as 272 keV=δm_N-$\varepsilon_\circ$ and 1212 keV=$8\times 16\delta'$.

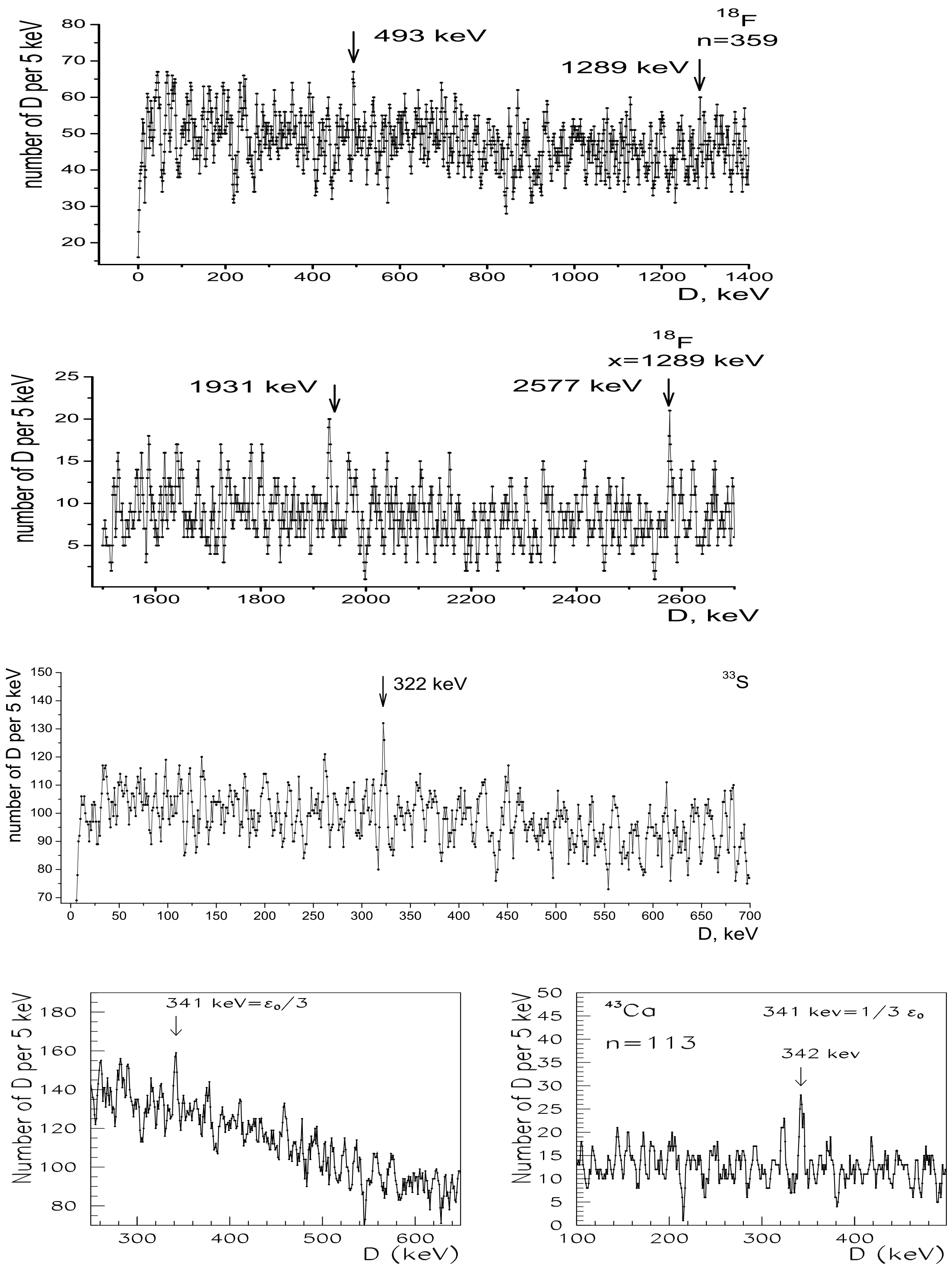

Fig. 3. *Top:* Spacing distribution between levels of near-magic nucleus ^{18}F and distribution of intervals adjacent to levels wich are taking part in the formation of the maximum at x=1289 keV in spacing distribution. Maxima at 1289 keV, 1931 keV and 2576 keV correspond to numbers 8, 12 and 16 of the period/parameter of the fine structure 161 $=17\delta'$.
Center: Spacing distribution in ^{33}S, maximum at 322 keV = 2×161 keV$=17\delta'$.
Bottom: Sum of spacing distribution in ^{141}Ca and ^{143}Ca (left) and spacing in ^{141}Ca (right) with the maximum at 341 keV$=2\times170$ keV$=2\times18\delta'$.

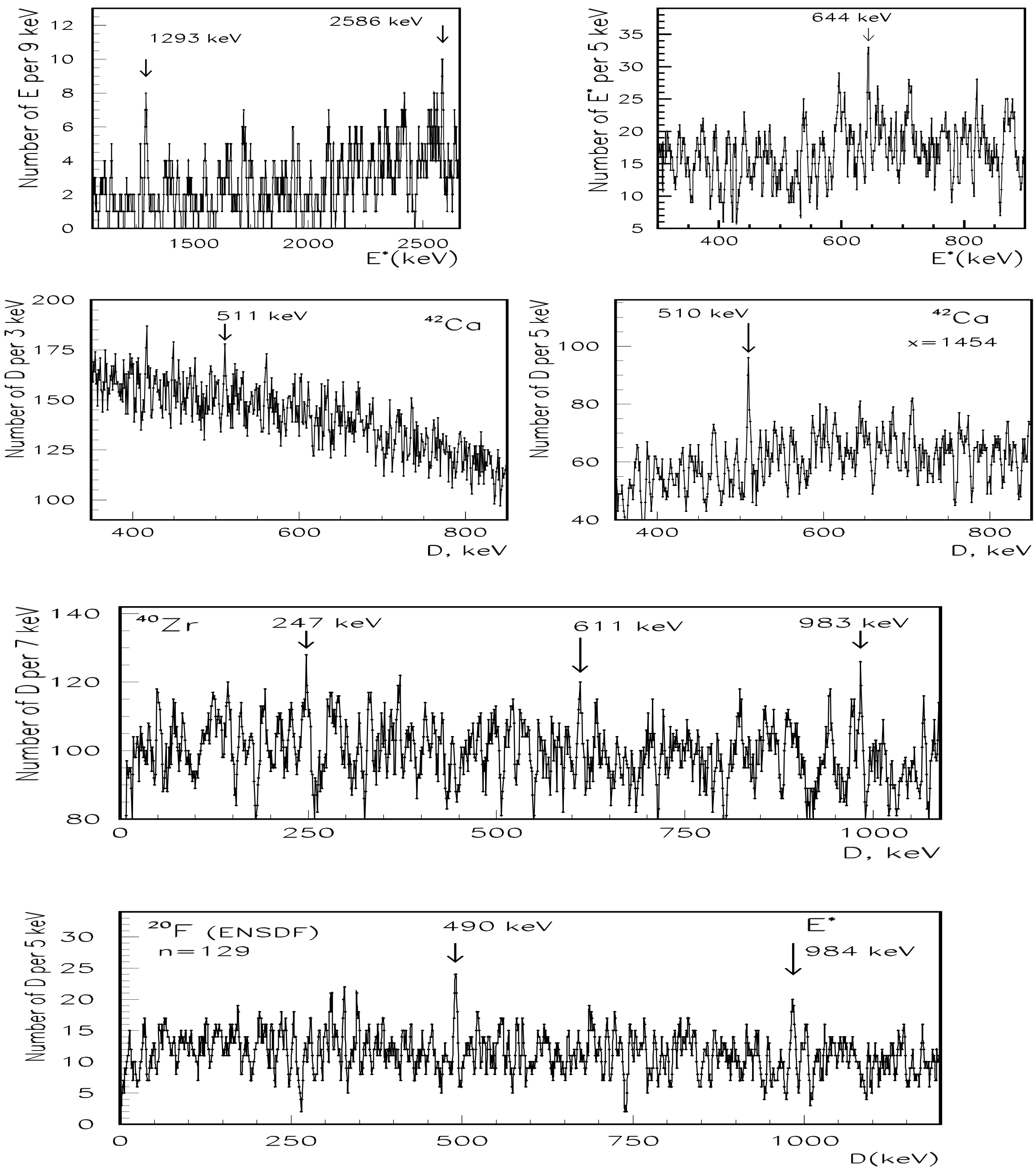

Fig. 4. *Top left:* Distribution of excitation energies in Z-odd nuclei with Z≤29 with maxima at δm_N=1293 keV and $2\delta m_N$=2586 keV (most of values are given in boxes in Tables 4-6).
Top right: Distribution of excitations in Z-odd nuclei around tin (Z=47-57). Maximum at 644 keV corresponds to n=4×17 with the period 9.47 keV coinciding with 511 keV/54=9.46 keV=δ'=9.51 =δm_N)/8×17 observed in positions of neutron resonances in nuclei N=82 [11].
Center: Spacing distribution in ^{42}Ca and distribution of intervals adjacent to stable intervals x=D=1454 keV=(9/8)δm_N. Maximum at 511 keV=m_e correspond to n=54; the value 1454 keV=(9/8)δm_N corresponds to the shift of the proton mass from the integer value of the electron mass 115δ-m_e (according to the above presented (CODATA relation)).
Bottom: Spacing distributions in ^{90}Zr and ^{20}F (the last line) with maxima at integer numbers M=2,5,8 and 4-8 of the fine structure parameter with n=13 (13×δ' = 123 keV), see Table 7).

3. Fine structure in particle masses

Recent analysis of nuclear binding energies and excitations of many magic nuclei allowed a confirmation of the tuning effect in particle masses. Stable mass/energy intervals coinciding or rationally connected with charge mass splitting of the nucleon δm_N=1293.3 keV and the lepton m_e=511 keV appear in the shift of the neutron mass relative to integer number of m_e. Using evaluated by CODATA exact ratio 1838.6836605(11) between masses of the neutron and the electron, we determine the shift δm_n=161.65(6) keV from integer number of m_e, namely 115δ - m_e. Period δ=16m_e, determined here with very high precision, is the common for many particle masses, for example, n=13 for the muon mass, n=16 for f_π, n=17 for the pion mass, n=18 for a half of nucleon Δ-excitation and n=115 for the neutron mass. This shift in the neutron mass is in a ratio 8×1.0001(1) with the nucleon mass difference δm_N. CODATA relation [24] means that nucleon masses are: $m_n = 115 \cdot 16 m_e - m_e - \delta m_N/8$ and $m_p = 115 \cdot 16 m_e - m_e - 9\delta m_N/8$.
The shift of m_e is presumably connected with the baryon number ($m_e/3$ per constituent quark) estimated in NRCQM (Nonrelativistic Constituent Quark Model) as M_q=$m_{\Xi^-}/3$= =441 MeV=3(ΔM_Δ=147 MeV), three-fold value of the pion-exchange interaction in NRCQM. Together with the meson constituent quark mass M''_q=$m_\rho/2$=409 MeV, they are in ratios with vector boson masses equal to the lepton ratio L=m_μ/M_e=13·16 − 1=207=M_Z/M_q=M_W/M''_q. Simultaneously, the ratio between masses of vector Z-boson and the muon $m_\mu/M_Z = 115.9 \cdot 10^{-5}$ is very close to QED-radiative correction $\alpha/2\pi = 115.9 \cdot 10^{-5}$. Such factor with the QED parameter $\alpha = 1/137$ was found between the scalar boson mass M_H=126 GeV, the parameter ΔM_Δ=147 MeV and $m_e/3$=170 keV. V. Belokurov and D. Shirkov suggested that the same QED correction can be applied to the electron mass itself. Cumulative effect in the constituent quark mass $M_q = 3 \cdot 18\delta$=3ΔM_Δ could result in the value close to m_e and could be connected with the origin of the mass m_e from physical condensate and the estimate of the Plank Mass value $M_P = L\Delta M_\Delta (\alpha/2\pi)^{-6}$ [25,26]. We draw attention to the five empirical relations based entirely on the unexpectedly accurate CODATA [24] relation with the real electron mass and the period 16m_e.

Recent analysis of particle masses and new nuclear data [5,6,11] confirmed CODATA relation between the nucleon (m_n, m_p) and the electron (m_e) masses. It is resulted in the presentation: $m_n = 115 \cdot 16 m_e - m_e - \delta m_N/8$ and $m_p = 115 \cdot 16 m_e - m_e - 9\delta m_N/8$ with shifts $\delta m_N/8$=161 keV and $m_e/3$=170 keV corresponding to the fine structure with the period δ'=9.5 keV and integer numbers n=17,18 (of this period). Such fine structure (with exactly the same period and n=13-18) was found in nuclear excitations of many near-magic nuclei. In Table 1 [13-23] these values are presented (in the bottom part) as parameters of the expression n·16m$_\mathrm{e}$$(\alpha/2\pi)^X$M with $\alpha/2\pi$=115.9·10^{-5} (close to 1/32·27=115.7·10^{-5}) and different values X, M and n=1,13-18.

The following five empirical correlations could be mentioned [13]: 1) Besides relations M_Z=LM_q and M_W=LM''_q the masses of scalars (M_H and M''_H=(2/3)m_t=2M^{L3}=116 GeV) can be estimated as $16 \cdot 18 M_q$ and $16 \cdot 16 M_q$ (Tables 7-9).
2) Well-known QED parameter for a short distance, $\alpha_Z = 1/129$ (an analog of 1/137) can be used for the interconnection of m_e, m_π and $m_\pi/(2/3)m_t$=M''_H=115 GeV=2M^{L3}=2·58 GeV (unconfirmed mass groupings found by ALEPH and L-3 collaborations at CERN). These relation between the top quark and electron masses could be helpful for the understanding of the origin of the color.

Table 7. Representation of parameters of tuning effects in particle masses (3 top sections) and nuclear data (bottom) with the expression n·16m$_e$($\alpha/2\pi$)^{X}M with different values of X–power at QED factor $\alpha/2\pi$ (α=1/137) and integers M and n=1,13-18. Boxed are five groups of values differing with $\alpha/2\pi$=115.9·10^{-5} [11].
Asterisc * marks stable intervals rational to charge mass splitting of the nucleon (n=17) double boxed in Tables 4-6; two asterisks ** mark stable phonon observed in nuclei with Z=50,52.

X	M	n = 1	n = 13	n = 16	n = 17	n = 18	n = 18·6
-1	3/2			m_t=172.0			
GeV	1	$16M_q=\delta^\circ$	$\boxed{M_Z=91.2}$	M_H=115		$\boxed{M_H=126}$	
	1/2	(m_b-M_q)		M^{L3}=58			
0	1	$2m_d$-$2m_e$	$\boxed{m_\mu=106}$	f_π=130.7	$\boxed{m_\pi\text{-}m_e}$	$\boxed{\Delta M_\Delta=147}$	$\boxed{2M_q}$
MeV	3			M"$_q$=$m_\rho/2$		M_q=441=ΔE_B	
1	1	$\boxed{16m_e=\delta=8\varepsilon_\circ}$	118		$\boxed{k\delta\text{-}m_n\text{-}m_e=}$	$\boxed{170 = m_e/3}$	Part.
					$\boxed{=161.651}$		mass
keV	8				δm_N=1293	CODATA	
1	1	$\boxed{9.5=\delta'=8\varepsilon'}$	122 (^{51}Cr)	152	Δ^{TF}=161	170 (^{101}Sn)	$\boxed{\varepsilon_o=2m_e}$
keV	1				160 (^{123}Sb)*	170 (N=51)	ε_o (^{10}B)
	2		247 (^{90}Zr)		320 (^{53}Ni)*	339 (^{59}Ni)	
keV	2				322 (^{33}S)	341 (Ca)	
	3				484 (E^*)	512 (Pd)	
	2					512 (^{55}Co)	
	4		493 (^{18}F)	606**	646 (^{37}S)*	682 (^{55}Co)	
	3		490 (^{20}F)		646 (^{53}Co)*		
	4		492***		648 (Pd)	682 (Te)	Nuclear
	5		611 (^{90}Zr)				
	5				644 (Sb)		
	8		984 (^{90}Zr)	1212 (E^*)	1293 (E^*)*	1360 (Te)	data
	8		984 (^{20}F)		1292 (^{38}S)*		
	12				1931 (^{18}F)		
	12				1943 (^{41}Ca)*		
	16				2576 (^{18}F)		
	16				2586 (E^*)*		
2	1-4	$\boxed{11=\delta''=8\varepsilon''}$	143 (As)	176	749 (Br,Sb)	393 (Sb)	$\boxed{\varepsilon'=1188}$
eV	4,8		570 (Sb,Th)		1500 (Pd,Hf)		Neutron
3	1						$\boxed{\varepsilon''=1.35}$

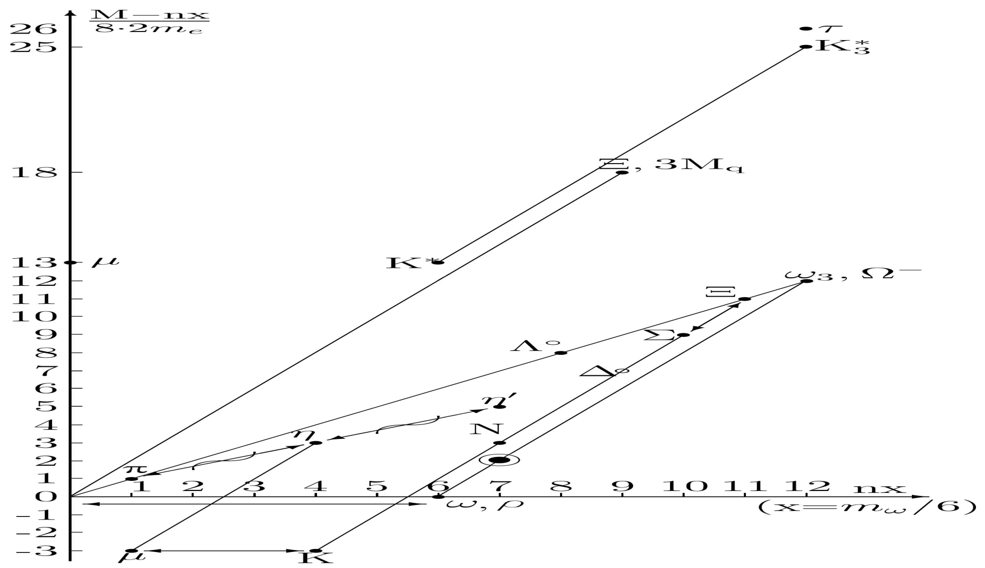

Fig. 3. Particle masses in two-dimensional representation [13-23]. Values along horizontal axis are given in units f_π=16 · 16m_e = 130.8 MeV=16δ, remainders - on vertical axis in units 16m_e=δ. Main lines correspond to ΔM_Δ=147 MeV=18δ - parameter of quark structure derived from nucleon Δ- excitation close to (1/3) of initial mass of constituent quark M_q and (1/9) of initial baryon mass 3M_q=m_Ξ (top). Nucleon mass (N) is on the line from kaon mass (K) to hyperon mass (Ξ). Nucleon mass within nucleus (circled point) is close to 6f_π+ΔM_Δ. Pion mass 140 MeV =f_π+δ is rational to masses of Λ, Ξ, Ω and is in equidistancy with pseudo-scalars $m_{\eta'}$-m_η=m_η-$m_\pi^\pm$ (crossed arrow). Tau lepton mass (top) is close to 12f_π+2m_μ (n=12·16+2·13).

Table 8. Comparison of particle masses with period 16m_e=8176 keV (numbers of periods k).

Particle	m_i, MeV	k	m_i-k·16m_e	Comm. (MeV)	Comments (in MeV)
μ	105.65837	13	-0.6294	-m_e-0.118	
τ	1776.86(12)	4 · 48· + 2·13		-5.51(1)	diff. -2m_e-(4.6=Δ)
f_π	130.7(4)	16		≈0	
$\pi^\pm$	139.5702(4)	17	+0.57624	+m_e+0.065	
Δ°-n	294.2(2)	36		2(ΔM_Δ=147.1)	ΔE_B=147.3 MeV
M_q NRCQM	441	3·18			ΔE_B=441 MeV
M_H/18·16	436	3·18-Δ		-5 = -Δ	
M_Z/L	440.49(5)	3·18	=441.50	M_Z=91187.6	-1.01(5)= -2m_e [28]
t-quark	173210(1000)	24x16x54			169540 MeV=24δ°
η'-η, η-$\pi^\pm$	409	50		≈0	
M_q^Δ NRCQM	410	50			ΔE_B=409 MeV
ρ	775.49(34)	96	-9.40(34)	-9.20 = -2Δ	
M_q'' NRCQM	387.63(12)	48	m_ρ/2	-4.60 = -Δ	
M_W/L	388.33	48	=392.45	M_W=80385	$M_W/L - M_q''$=0.70(12)
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
Σ°	1192.64(2)	146	-1.05(2)	-0.51·2=-1.02	
Ξ°	1314.86(20)	161	-1.47(20)	-0.51·3=-1.53	

3) The origin of the dark matter could be connected with the observed shifts in strange octet baryons (two bottom lines in Table 8) and with the above discussed interconnection between m_e and heavy fermions ($m_e=(\alpha/2\pi)/M_q$).
4) Evolution of nucleon mass (Fig.3) from the initial value $3M_q$ (top) to the value $6f_\pi+\Delta M_\Delta=2M''_q+\Delta M_\Delta$ (bottom) means the distinguished character of NRCQM parameters based on QCD gluon quark-dressing effect. Progress of nuclear physics in a view of the presence of correlations between m_e and heavy fermions M_q and M''_q (plus $f_\pi, m_\pi, \Delta M_\Delta$) which are parameters of nuclear models is in line with F. Wilczek expectation about a future great role of "nuclear chemistry" [12].
5) Confirmation with nuclear data analysis of intervals/periods Δ (observed in particle masses, boxed in Table 8, including tau-lepton mass) put forward a problem of symmetry-motivated interpretation of tuning effect parameters.

To explain the period of $\delta = 16m_e=2\Delta-2m_e$ (with $\Delta=9m_e$) the symmetry motivated arguments were searched [13-23] starting with indications on the reality of integer ratios and long-range correlations in particle masses and nuclear data. Relation between the constituent quark mass $M_q = 3\Delta M_\Delta$ could be a reflection of the influence of the physical condensate [27] (and might be connected with the gravitation [25,26]). Analysis indicates on the existence of small shifts about 4.6 MeV=$\Delta = 9m_e$ directly observed in the pion's mass splitting and τ lepton mass shift (boxed in Table 8). CODATA parameter $\delta = 16m_e$ can be considered as a result of the relation 1:9=1:(3×(9/3=1/3+8/3)) mentioned in [15-18] after comparison of the lepton ratio L with number of fermions in the central field (Table 9). Integer relation 9=8+1 could be connected with the new value of the principal quantum number in the fermion shell-like system (in accordance with V. Gribov suggestion that three colors are corresponding to three axes in the inner space):

$$\begin{aligned} &= (1/3)m_e+(8/3)m_e \qquad\qquad &&= (1/3)M_q+(8/3)M_q \\ 9m_e &= (1/3)m_e+(8/3)m_e \qquad\qquad 9M_q &&= (1/3)M_q+(8/3)M_q \\ &= (1/3)m_e+(8/3)m_e \qquad\qquad &&= (1/3)M_q+(8/3)M_q \end{aligned}$$

Table 9. 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).

N ferm.	N = 1	16	16·13-1	16·16	16·18
Part./par.	m_e/M_q	δ/δ°	m_μ/M_Z	$f_\pi/(M'_H = 2m_t/3 = 2M^{L3})$	$\Delta M_\Delta/M_H$
Ratio	$116\cdot10^{-5}$		$116\cdot10^{-5}$	$116\cdot10^{-5}$	$116\cdot10^{-5}$
Nr	(1/16)	(1)	12+1	16	18
States	$1s^4_{1/2}$		$1s^4_{1/2}$, $1p^8_{3/2}$, $1p_{1/2}$	$1s^4_{1/2}$, $1p^{8,4}_{3/2,1/2}$	
Comm.			$\boxed{\text{hole in } 1p \text{ shell}}$	filled shells	

4. Conclusions

Performed here and in [11, 13-23] analysis of particle masses and nuclear data confirmed the presence of the so-called CODATA relation with the fine structure parameters 161 keV=$\delta m_N/8$ and 170 keV=$m_e/3$ as well as the scaling factor $\alpha/2\pi$ equal to QED radiative correction. Possible origin of the baryon number and the color is due to involvement of 1/3 part of the electron mass. Universal character of the electric charge and the spin should be theoretically combined with observed empirical CODATA-relations. These correlations found long ago [25,26] are confirmed now with analysis of new nuclear data [5,6]. The role of nuclear data in the study of tuning effect is very important.

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