ANALYSIS OF NONSTATISTICAL EFFECTS IN NEUTRON RESONANCES

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1 Introduction

In this report we discuss nonstatistical effects in neutron resonances as a reflection of a "tuning effect" in nuclear data. The study of spacing distributions in neutron resonances in near-magic nuclei permitted a conclusion that stable intervals between resonances are close or rational to the stable intervals in low-lying levels [1]. On the other hand systematical effects in excitations (E^*) and spacing (D) in near-magic nuclei are described by parameters close to that observed in differences of nuclear binding energies ΔE_B [2,3]. This concerns such common parameters as ε_o=1022 keV and values rationally connected with ε_o (where $\varepsilon_o/2$ is close to the electron rest mass m_e). First we discuss effect in ΔE_B.

In the next section we consider the systematic character of excitations in near-magic nuclei which permitted to introduce the parameter D_o=1293 keV close to the mass difference of nucleons as a part of series of stable intervals rationally connected with D_o (period $D_o/8$=161 keV) seen in general E^*-distributions and in data for some near-magic nuclei.

In conclusion we consider some features of tuning effects in nuclear data and particle masses in line with suggestions and findings made by S.Devons [4] and Y.Nambu [5,6].

The character of data on nuclear binding energies E_B, namely the grouping of ΔE_B in nuclei differing by nuclear clusters: four protons, four α-clusters and ^{6}He-cluster (see 3 parts of Fig.1) are the major arguments for the presence of general "tuning effect" in nuclear data. By the substitution of the experimental values E_B [8] with the calculated values (according to different models like FRDM etc.) it was shown that models do not describe the observed correlation (exact rational ratios) in ΔE_B of the near-magic nuclei.

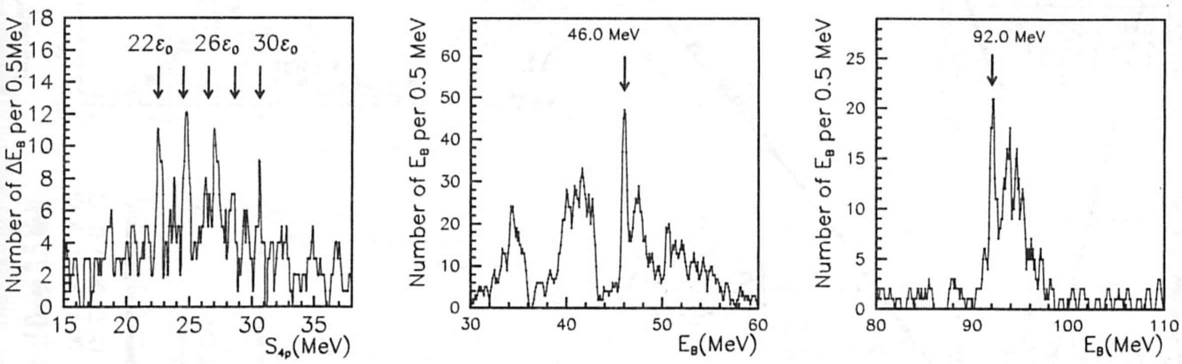

Fig. 1. *Left:* Distributions of four-proton separation energies S_{4p} in N-even nuclei with N=50-82; *Center and right:* Distributions of ΔE_B in N-even nuclei differing by one and two ^{6}He configurations; parameters ε_o and Δ=(9/2)ε_o are discussed in the text.

A standard procedure for the determination of the residual interaction between valence nucleons consists in calculation of differences of separation energies of valence proton or neutron in nuclei with different number of nucleons of the other type (ΔS_N=ε_{NN}). In Fig.2-3 a linear dependence of 51-th valence proton separation energy (upon N) is shown.

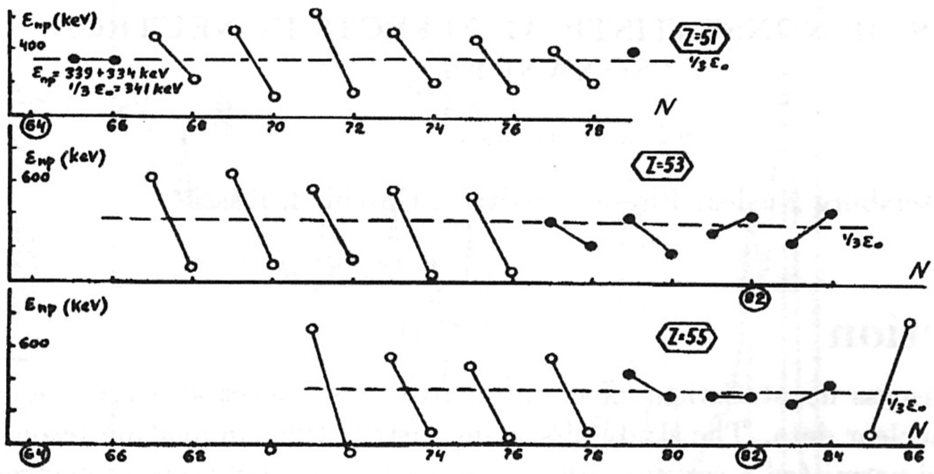

Fig.2. Parameters of the residual interaction ε_{np} from differences of S_p in Z-odd nuclei differing with ΔN=1. Mean value 341 keV=$\varepsilon_o/3$ is given by the horizontal line [7].

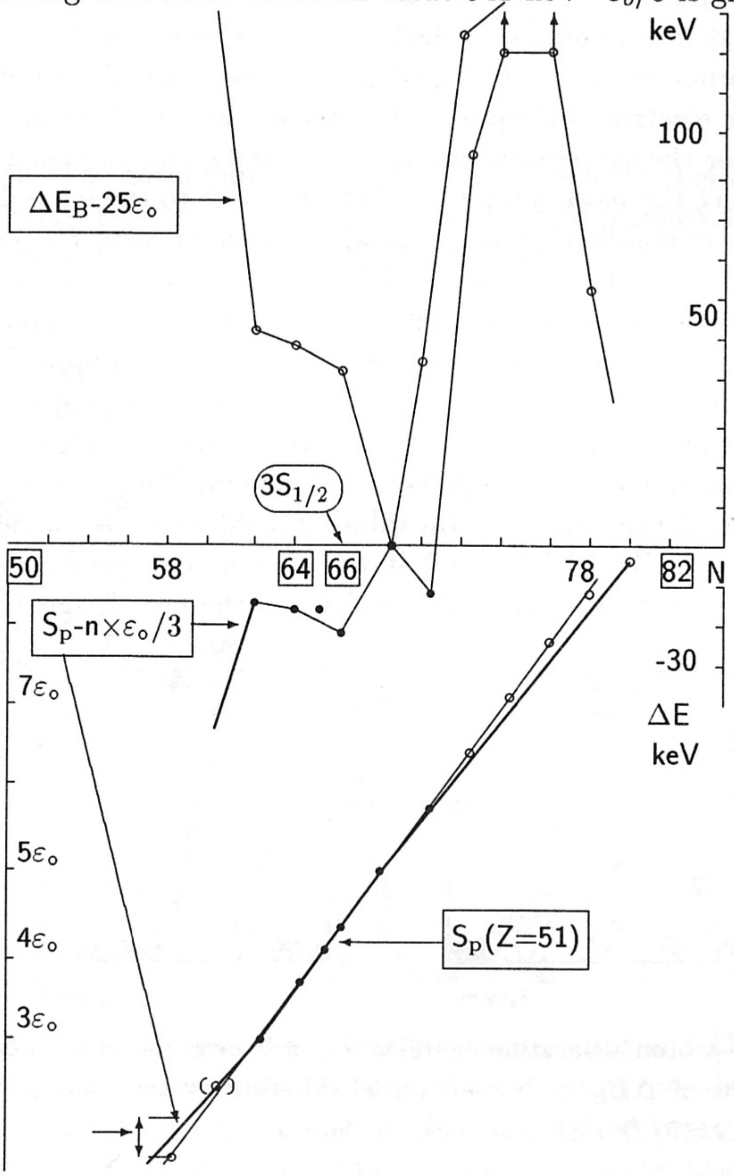

Fig.3. *Bottom:* Separation energies S_p of the valence 51-th proton and differences between S_p and the integer number of the period $\varepsilon_o/3$=340 keV (dark circles) as a function of N. *Top:* Difference between $\Delta E_B=\Sigma(S_p(Z=50)+S_{2n}(Z=50))$ and $25\varepsilon_o$ (see Table 1).

Parameters ε_{pn} for nuclei with Z=51,53,55 presented in Fig.2 show N-even-odd effect which becomes small in the regions of filling up of the well-known shells N=64, 82 (dark circles). The same stable parameter 340 keV=$\varepsilon_o/3$ was found in case of 83-th proton and 83-th neutron. Similar stabilizing effect (with $\varepsilon_{pn} \approx$680 keV =$2\varepsilon_o/3$) exists in nuclei with valence proton Z=29. Values S_p themselves are close to integers (n) of $\varepsilon_o/3$ (Table 1).

Table 1. Comparison of valence proton Z=29 and Z=51 separation energies with integers (n) of the parameter $\varepsilon_o/3$=341 keV (in keV) [7]. Boxed are small differences S_p-n·341 keV and N corresponding to the closed subshells (Fig.2-3. Values S_p from FRDM are given below.

^{A}Z	^{57}Cu	^{59}Cu	^{61}Cu	^{63}Cu	^{65}Cu	^{67}Cu	^{69}Cu	^{62}Zn
S_p,keV	695	3418	4801	6122	7452	8561	9543	6477
$n \times \varepsilon_o/3$	682	3407	4770	6132	7495	8517	9539	6473
n	2	10	14	18	22	25	28	19
diff.	13(18)	$\boxed{11(1)}$	$\boxed{31(1)}$	$\boxed{10(1)}$	$\boxed{43}$	$\boxed{44(18)}$	$\boxed{4(18)}$	$\boxed{4(10)}$
N	58	60	62	64	$\boxed{65}$	66	$\boxed{68}$	70
^{A}Z	^{109}Sb	^{111}Sb	^{113}Sb	^{115}Sb	^{116}Sb	^{117}Sb	^{119}Sb	^{121}Sb
S_p,keV	1541	(2928)	3044	3734	4074	4406	5109	5779
$n \times \varepsilon_o/3$	1533		3066	3748	4088	4428	5110	5792
n	(9/2)		9	11	12	13	15	17
diff.	$\boxed{8(47)}$		$\boxed{22(22)}$	$\boxed{14(20)}$	$\boxed{14(7)}$	$\boxed{22(10)}$	$\boxed{1(9)}$	$\boxed{13(3)}$
$\varepsilon_{p2n}, \boxed{\varepsilon_{pn}}$				690	$\boxed{340}$	672	703	670
S_p, FRDM	759		2308	3238	4039	4278	5198	5978

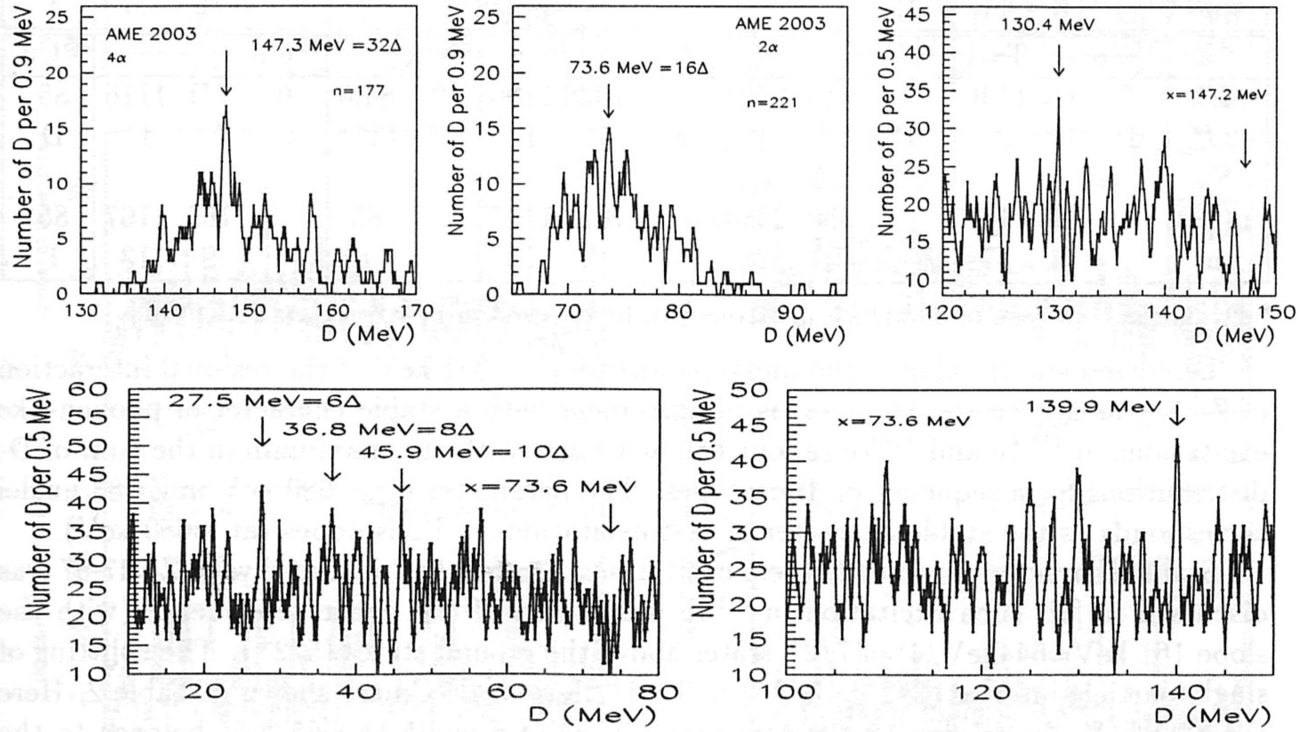

Fig.4 *Top:* ΔE_B-distribution in nuclei Z≤26) differing by four and two α clusters.
Top right and bottom: Distribution of ΔE_B adjacent to x=147.2 MeV and to x=73.6 MeV.

An example of a study of correlations in Δ_B is shown in Fig.4. The correlation program "AIM – Adjacent Interval Method" detects the appearance of triplets in spectra of nuclear binding energies (E_B) or excitations. AIM plots the distribution of spacing (D^{AIM}) from those levels (states) which form stable intervals D=x under investigation. Grouping of Δ_B in light nuclei (Z≤26) differing by four and two α-cluster configurations ($\Delta Z=\Delta N$=8,4) which take place at Δ_B=147.2 MeV=32Δ and 73.6 MeV=16Δ were checked by observation of other Δ_B-grouping in AIM intervals (for x=147.2 MeV and x=73.6 MeV, Fig.4 bottom). Parameter $\Delta=(9/2)\varepsilon_o$=4.6 MeV was found [2,3] from the grouping of Δ_B=n·Δ (n=9,10,11) in nuclei differing by ^{6}He-cluster (N≤126,82,50).

2 Tuning effect in nuclear excitations

Stable character of energy intervals due to valence nucleon interactions was studied also in data for nuclear excitations: interval 340 keV and its doubled value 682 keV were seen as maxima in D-distributions for ^{43}Ca, ^{43}Sc, ^{47}V, ^{57}Ni, ^{62}Ni [2] and ^{55}Fe. Data on E^* and spectroscopic factors (S_N) collected recently in CRF (Combined Reaction File [8]) permitted to show that a periodicity in E^* in nuclei around ^{56}Ni with the period 85 keV=$\varepsilon_o/12$ (Table 2, D=85 keV seen in ^{55}Co, ^{65}Cu [2]) is connected with the large S_N.

Table 2. Comparison of energies and S_N with integers of $\varepsilon_o/12$=85 keV (E^* in 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

* D=340 keV in case of 3 valence neutrons can be checked in neutron data (EXFOR).

Discussed stable value of the mean parameter ε_{pn}=341 keV of the residual interaction of Z=51 valence proton (Fig.2-3) is in agreement with a stable character of phonon-like excitations in ^{118}Te and ^{126}Te (about 680 keV) and with the maximum in the sum of D-distributions for a sequence of Te-isotopes. The parameter ε_{p2n}=680 keV in Z=83 nuclei corresponds to the stable character of first excitations in Po-isotopes (at ≈680 keV).

Stable character of somewhat less excitations E^*=644 keV in nuclei with Z=47-57 was discussed in [9]: such excitation in ^{111}Sb was a part of the linear dependence (with the slope 161 keV=644keV/4) of $7/2^+$ states above the ground states ($5/2^+$). The splitting of single-particle interval ($3/2^-$ – $5/2^-$) in T=3/2 levels of ^{55}Co are shown in Table 2. Here D=1022 keV=ε_o belongs to the sequence 170 keV×n while D=965 keV belongs to the sequence 161 keV×n, n=6. Intervals D=ε_o, D=$\varepsilon_o/2$ and 324 keV=965 keV/3 are forming stable triplets in ^{55}Co states observed by AIM.

Stable intervals D=D_o=1293 keV=≈ 161×8 were found in ^{32,33}S. In many nuclei E^* at (1/2)D_o=647 keV, D_o=1293 keV, (3/2)D_o=1942 keV and 2D_o=2586 keV were noticed [10]. Data from CRF on E^* and S_N for nuclei with N=21 (Table 3) were used to check a linear trend with the slope 647 keV derived from the ratio 1942.8/646.2=3.006 in E^* of $7/2^-$ states with large S_N. Excitations E^*=159–484 keV in ^{33}Mg triplet correspond to (1/4)-(3/4) of D_o/2=647 keV. Data for ^{35}Si, ^{32}Si and ^{38}S are given for comparison.

Table 3. Comparison of energies with integers of 647 keV=$D_o/2$ (E^* in keV, large S_N)

^AZ	^{41}Ca		^{39}Ar		^{37}S		^{35}Si	^{33}Mg (3^+)		^{32}Si		^{38}S	
E^*	0	$\boxed{1943}$	0	1267	0	$\boxed{646}$	910	159	484	0	$\boxed{1942}$	0	$\boxed{1292}$
$2J^\pi$	7^-	3^-	7^-	3^-	7^-	3^-	(3^-)	(7^-)	(3^-)	0^+	2^+	0^+	2^+
S_N	0.85	0.67	0.64	0.57	5.54	1.75				1.6	5.3		
n$\frac{D_o}{8}$	0	1941	0	1293	0	646		161	483		1941		1293
n		12		8		4		1	3		12		8

Close to each other stable intervals D=322-323 keV and 484-486 keV were found in spectra of ^{110}Cd and ^{111}Cd (Fig.5 top, numbers of levels 287 and 113). These D were checked by AIM-analysis by fixation of D=x=647-484 keV and D=x=322-486 keV (Fig.5). All maxima correspond to series of values n×161 keV=n×D_o/8 (n=1,2,3,4,5,6). The intervals are close to 2^+ excitations in ^{106,108,110}Cd (632, 632, 658 keV) and $E^*(\Delta J=1^+)$ in ^{111}Cd.

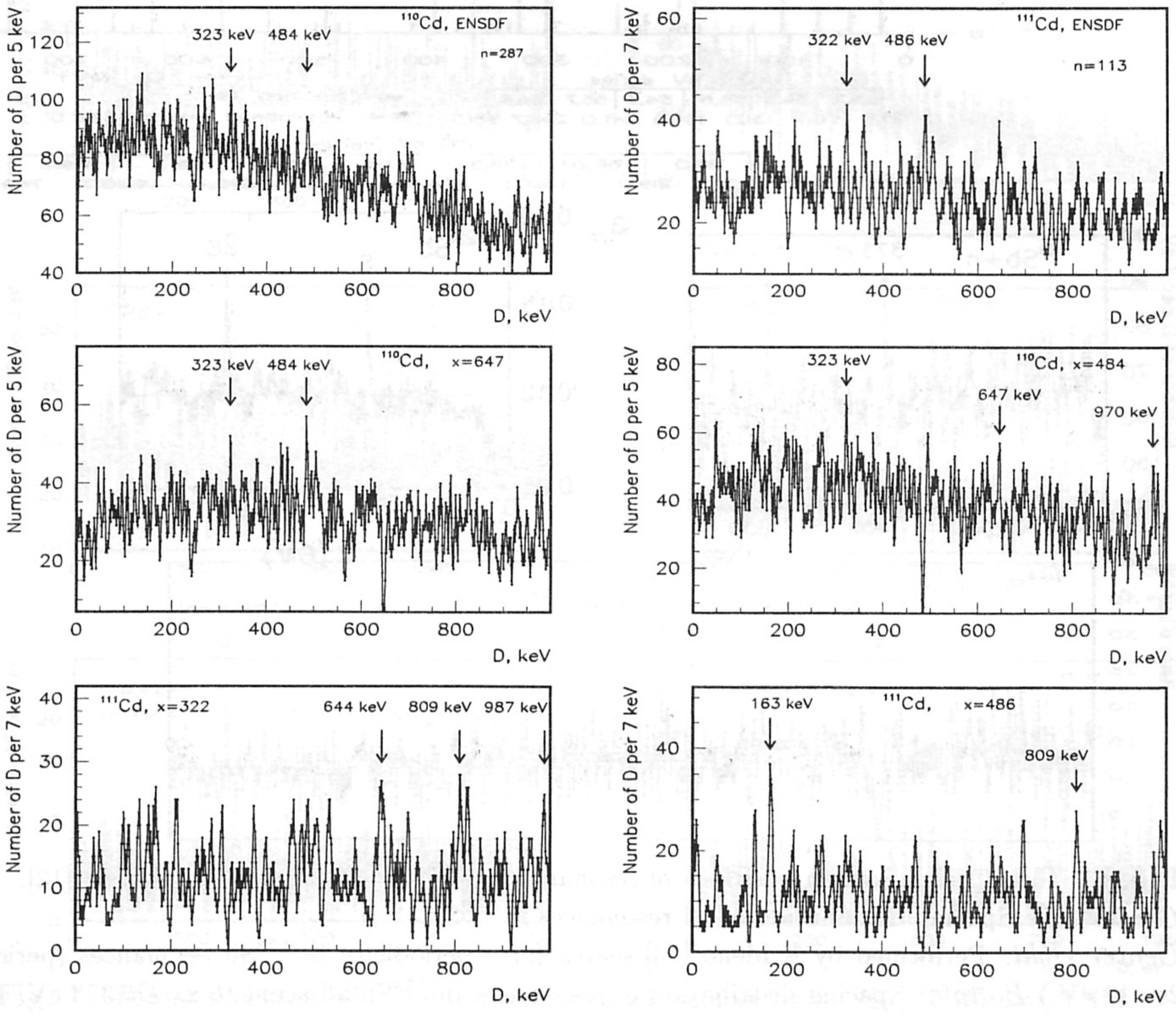

Fig. 5. *Top:* D-distribution in all levels of ^{110}Cd and ^{111}Cd. *Center and bottom:* Distribution of intervals adjacent to x=D=647 and 484 keV in ^{110}Cd and x=D=322 and 486 keV in ^{111}Cd.

3 Superfine structure in neutron resonance positions

In a study of nonstatistical effects in complex nuclear spectra seen as neutron resonances different method of correlation analysis should give consistent results. For example, four pictures in Fig.6 illustrate results obtained for near-magic compound ^{124}Sb (Z=50+1) where earlier [11] intervals rational to the period 5.5 eV were noticed.

1) M.Ohkubo [12] marked the sequence of resonances (with the period 88 eV) from 131 eV up to the second strongest resonance at 750 eV (see two-dimensional plot of the reduced widths vs. the energy in Fig.6 top). From the ratio 131/88=1.49 one can conclude that resonance positions are expressed in odd units of 44 eV, from n=3 up to 17. Additional strong resonances correspond to n=9 (396 eV) and n=13 (572 eV).

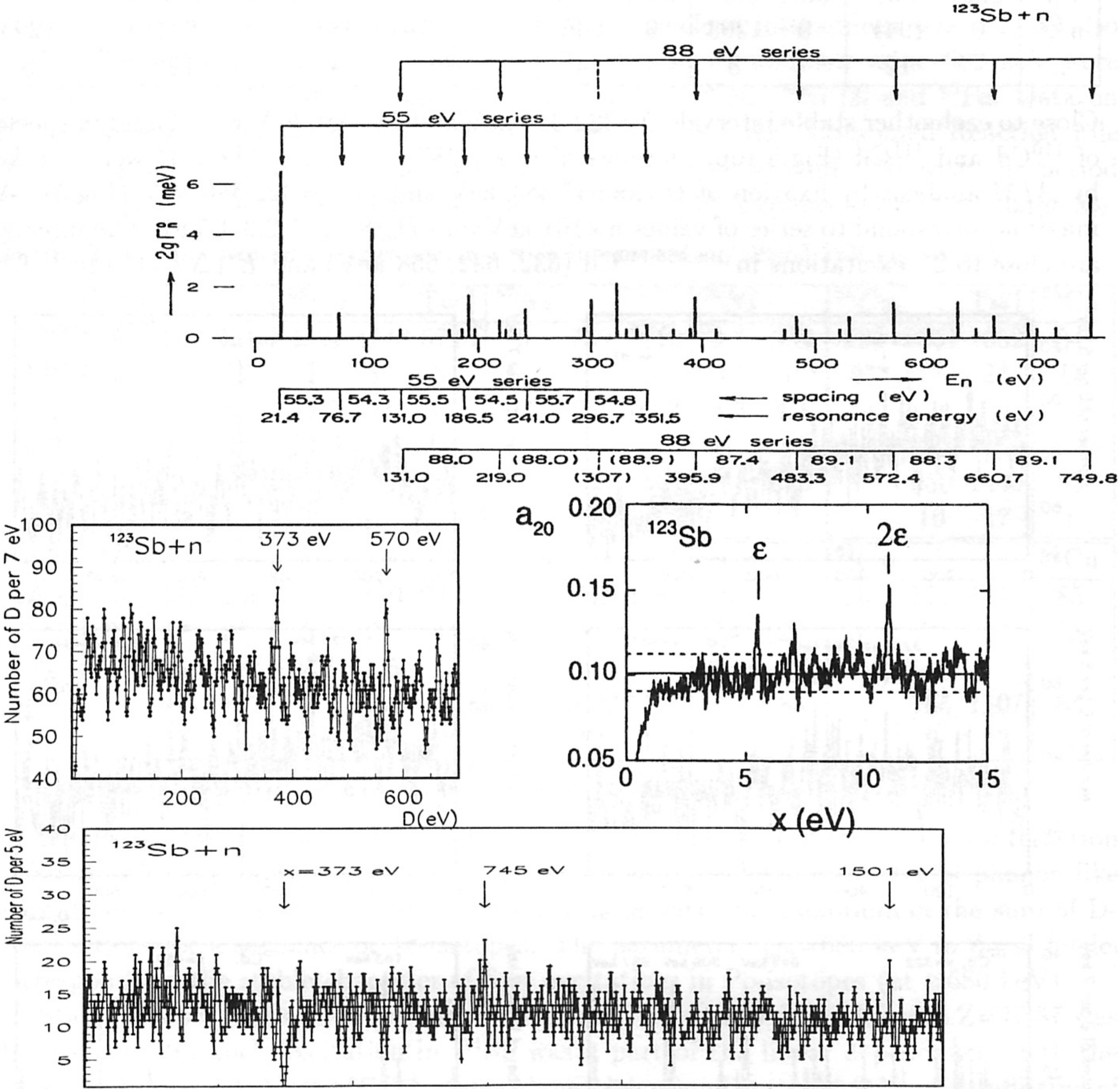

Fig. 6. *Top:* Correlations in positions of resonances in ^{123}Sb discussed by M.Ohkubo [12]. *Center left:* Spacing distribution of all resonances in ^{123}Sb. *Center right:* Performed by K.Ideno [13] search for a periodicity in ^{123}Sb resonances (period 2ε=11 eV.) *Bottom:* Spacing distribution of resonances in ^{123}Sb adjacent to x=D=373 eV.

2) K.Ideno developed several methods of the study of superfine structure in resonance positions [13-15]. His observation of the distinguished period 11 eV=44 eV/4 in the same data shown in Fig 6 (center right) is complementary to the results by M.Ohkubo.

3) In spacing distribution of all resonances (mainly s-resonances) of ^{123}Sb shown in Fig.6 (center left) one can see two clear maxima which correspond to n=13 and n=17 with the period found by M.Ohkubo in resonance positions.

4) It is shown by AIM-analysis [16] that intervals 373 eV, 745 eV and 1501 eV (with a ratio 1:2:4) are appearing as triplets in highly excited states of ^{124}Sb (Fig.6, bottom). Stable intervals 750-1500 eV were found also in D-distributions for ^{80}Br, ^{104}Rh and ^{105}Pd (Fig.7). In the distribution of intervals adjacent to D=1497 eV in resonances of ^{105}Pd large interval D=7498 eV with values close to 5×1497(2) eV=7485(10) eV and intervals equal to its half were also observed.

Stable intervals and resonance positions in ^{124}Sb (n=9,13,17) and stable intervals in ^{76}As (n=13/4 period 44 eV) noticed by K.Ideno and M.Ohkubo are presented (and boxed) in Table 4. Stable intervals in ^{233}Th, ^{88}Sr, ^{134}Cs and grouping of $(E^*–S_n)$ in nuclei with Z=31-56 and 56-94 were also included in this Table.

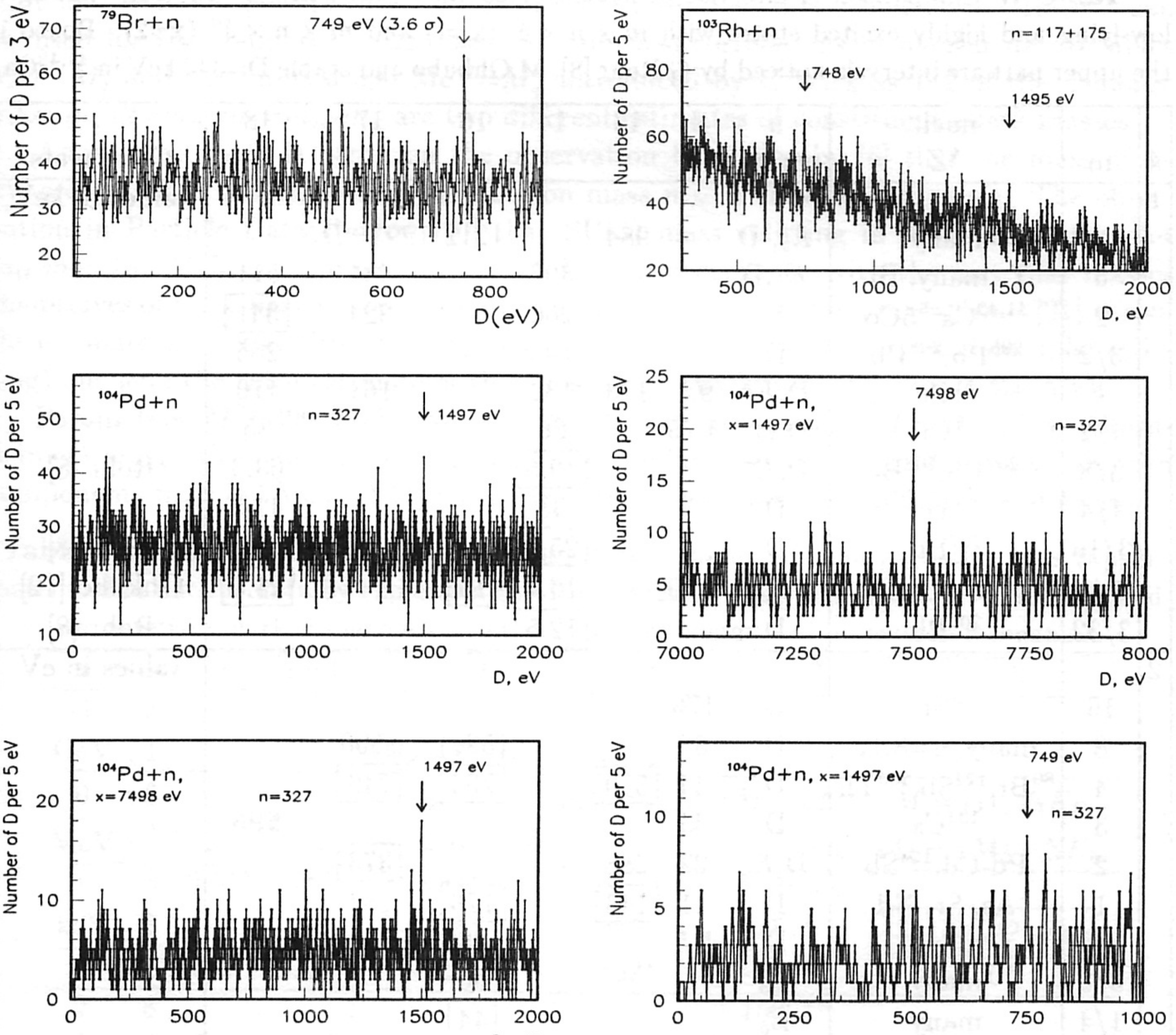

Fig. 7. *Top and center left:* D-distributions of all resonances in ^{79}Br, ^{103}Rh and ^{104}Pd. *Center right and bottom:* Spacing distributions of resonances in ^{104}Pd adjacent to interval x=1497 eV and x=7498 eV (distribution only in downward direction).

The above discussed value D_o=1293(2) keV coincides with the nucleon mass difference 1293.3 keV. Together with the coincidence of the nuclear parameter ε_o with $2m_e$ and the third coincidence, namely, of the electromagnetic mass difference of the pion with the nuclear parameter $\Delta=9m_e$=4.6 MeV, they all were considered as signals about the presence of the tuning effect in nuclear data similar to that in the particle masses.

It was concluded in [17] that:

1) intervals of the fine-structures 161 keV=$D_o/8$ and 170 keV=$\varepsilon_o/6$ are in the same ratio 17/18 as m_π=140 MeV and 147 MeV – the half of the nucleon Δ-excitation (294 MeV/2);

2) the dimensionless ratio between these two pairs of hadronic parameters, namely the ratio (D=341 keV=$\varepsilon_o/3$)/294 MeV=$1.16 \cdot 10^{-3}$ or $1/(27 \cdot 32)=1.157 \cdot 10^{-3}$ is close to the QED radiative correction $\alpha/2\pi=1.159 \cdot 10^{-3}$. It means that empirically observed parameters of the fine- and superfine structures (δ'=9.5 keV and δ''=11 eV) form the ratio close to $\alpha/2\pi$ between themselves and with the value $16m_e=\delta=2\Delta-\varepsilon_o$=8.176 MeV.

Different stable intervals observed in neutron resonances and in low-lying levels are displayed in Tables 4 and 5 in accordance with this empirical findings: D=$m \times n \times \delta'$ (x=1) and $m \times n \times \delta''$ (x=2).

Table 4. Comparison of intervals in neutron resonance positions (E*–S_n) and spacing in low-lying and highly excited states with $m \times n \times \delta'$ (x=1) and $m \times n \times \delta''$ (x=2). Boxed in the upper part are intervals noticed by G.Rohr [8], M.Ohkubo and stable D=340 keV in ^{41,43}Ca.

x	m	nucl. ${}^AZ$	n param.	1	13	14	16	17	18	Comments
1										values in keV
	8	many	E_o, D		984		1212	1293=D_o		
	3	Y, many, Bi,	E_γ,D			397		484	511	
	2	^{41,43}Ca ^{55}Co	D			266		324	$\boxed{341}$	
	3/2	^{205}Pb,^{208}Pb	D			198			255	
	1	^{51}Cr	D,E^*	9.5	123	132		161	170	
	1/2	^{51}Cr	D,E^*	4.75		66			85	
	3/8	^{207}Pb,^{208}Bi	D,E^*			$\boxed{49.5}$			63.3	Rohr [8]
	1/4	^{57}Fe	D			33			42.5	
	3/16	^{207}Pb	D			$\boxed{25.0}$				Rohr [8]
	1/8	^{140}Ce,^{207}Pb	E_o	1.19		16.4	$\boxed{19}$		$\boxed{21.5}$	Ohkubo [12]
	3/32	^{207}Pb	D			$\boxed{12.5}$				Rohr [8]
2										values in eV
	16	^{88}Sr	D	176						
	8	many, n=8,12	D	88			(528)	1500		
	4	^{80}Br,^{124}Sb,^{233}Th	D	44	$\boxed{570}$		$\boxed{704}$	$\boxed{749}$		
	3	^{134}Cs	D	33					**595**	
	2	Pd-Cd,^{124}Sb	D,E_o	22	288			$\boxed{373}$		
	1	As, Sr, Nd	D	11	$\boxed{143}$		$\boxed{176}$	187		
	1/2	many	D	5.5			88			
	3/8	many	E_o				66			
	1/4	many	E_o				$\boxed{44}$			
	1/8	^{233}Th	E_o				$\boxed{22}$			

4 Tuning effect in particle masses

The presence of similar stable intervals in nuclei where different shells are filling up was interpreted as a manifestation of a tuning effects of the general origin connected with the nucleon structure as it was suggested by S.Devons. In existing constituent-quark models nucleon mass is treated as a sum of three fermion components of about 300-400 MeV. The following three constituent quark masses were considered.

The value M_q=441 MeV close to 3/2 of the well-known value of nucleon Δ-excitation (294 MeV) was introduced by R.Sternheimer and P.Kropotkin [18,19] as $3/2(m_\Delta\text{-}m_N=m_\eta\text{-}m_\mu=m_N\text{-}m_K=m_\Xi/3=M_q$. It can be considered as one third of the "initial mass" of non-strange baryon $M_N^{init}=M_\Delta^{init}\approx$1350 MeV (that's the theoretical mass before inclusion of the residual quark interaction) in the Quark Model with Goldstone Boson Exchange [20] M_N^{init} which is close to the octet Ξ^--hyperon mass (1324 MeV=3×441 MeV=$3\times M_q$) due to the compensation of the mass reduction from quark interaction ($\approx$294 MeV) and the mass increasing from the strangeness (S=2, $m_s\text{-}m_d\approx$150 MeV).

It was noticed in 70-ties [17] that the parameter $\varepsilon_o/2$=511 keV in nuclear data (or m_e) forms the ratio $1/(32\cdot27)=\alpha/2\pi$ with the Sternheimer's mass parameter. It means that four different powers (n=-1,0,1,2) of QED radiative correction $\alpha/2\pi=1.16\cdot10^{-3}$ can be used for the comparison the observed empirical correlations in nuclear data (Tables 4,5). M_q and the interval 390 MeV=M_q'' introduced by G.Wick as 1/2 of the ω-meson mass $m_\omega/2=m_N\text{-}m_\eta=m_K\text{-}m_\mu$ are two different estimates of constituent quark masses.

Another estimate is based on the observation by Y.Nambu [6] that the mass of Λ-hyperon is close to $8m_\pi$ (while the nucleon mass m_N is close to $6m_\pi+m_\mu$). The observation in Particle Data Review [20] that SU(3) mass splitting in the baryon decuplet $m_\Omega\text{-}m_\Xi$=137 MeV is close to m_π=139 MeV is in accordance with the fact that masses themselves of these baryons are close to integers of m_π ($m_\Omega=12m_\pi$, $m_\Xi=11m_\pi$) [21]. From the estimate of the constituent strange baryon quark mass $m_\Omega/3=4m_\pi$ (and decuplet splitting) one gets the third estimate of the nonstrange quark mass $M_q'=3m_\pi$=420 MeV.

Parameters M_q''=390 MeV (Wick), $M_q'=3m_\pi$ (Nambu) and M_q=440 MeV (Sternheimer) are in the relation 16:17:18 and the similar relation 17:18:13:1 exists between components m_π=139 MeV, ΔM_Δ=147 MeV, the muon mass m_μ=106 MeV and $\delta=16m_e$.

Table 5 from [1]. Representation of parameters of tuning effect in particle masses (upper part) and in nuclear data by expression $(\text{n}\times16m_e(\alpha/2\pi)^x)\times m$ with $\alpha=137^{-1}$. Asterisk and two asterisks mark stable nuclear intervals at low energy and in neutron resonances.

x	m	n=$\frac{1}{8}$	n=1	n=13	n=16	n=17	n=18
-1	3				$\boxed{2m_t=348}$		
GeV	1			M_Z=91.188	M_H=115		
0	3				$M_q''=m_\omega/2$	$\boxed{M_q'=420}$	M_q=441, ΔE_B
MeV	1	ε_o	$16m_e$	m_μ=105.658		$m_\pi-m_e$	147=ΔM_Δ, ΔE_B
1	8	9.5**	76*	984*	1212*	1293=D_o	
keV	3			368*	455*	481*	$\boxed{511=\varepsilon_o/2=m_e}$
	1	1.2*	9.48*	123*	152*	161*	170*
2	8					1500**	
eV	4	5.5*	44**	572**		750**	
	1		11**	143**	176**	187**	

Three above discussed estimates of constituent quark masses are shown together in two-dimensional presentation in Fig.8. Masses (M_i) are expressed as "integers" of the period $16\cdot16m_e$=130 MeV (close to 1/3 of Wick's interval 390 MeV=$m_\omega/2$) and "residuals" M_i-k×($16\cdot16m_e$=δ) plotted along the vertical axis in $16m_e$=δ units. Masses integer with pion mass are shown on the line with the minimal slope. Masses and mass differences which are integer with 147 MeV (half of Δ-excitation, m_{Ξ^-}, M_q etc.) correspond to lines with the large slope (parallels correspond to equal periods in mass differences).

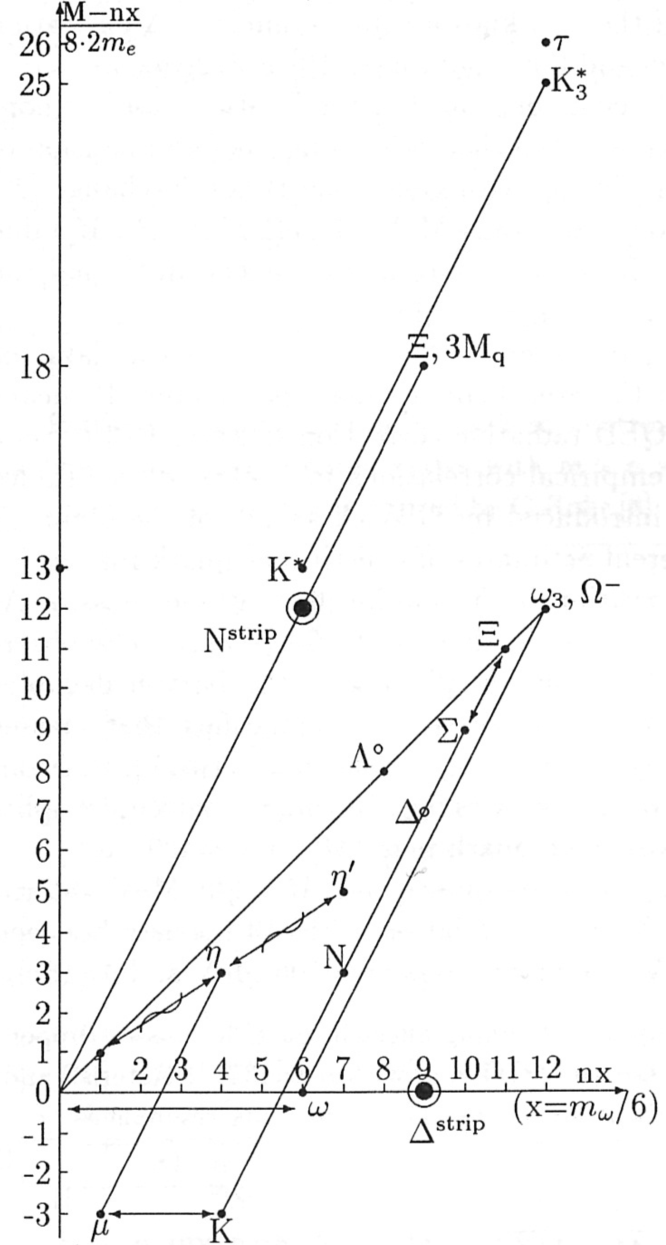

Fig.8. Position of different mass intervals and τ-lepton mass close to integer number of M_q=m_{Ξ^-}/3 on the two-dimensional mass-presentation with the horizontal axis in units $16\cdot16m_e$ close to $m_\omega/6$ and M_i-k×($16\cdot16m_e$=δ) along the vertical axis in $16m_e$ units. Two lines with the discrete slopes correspond to the pion mass (140 MeV=$m_\omega/6+\delta$ and to the nucleon Δ-excitation $m_\omega/6+2\delta$. Crossed arrows correspond to intervals m'_η-m_η=m_η-$m^\pm_\pi$ (n=50). Parameters Δ^{strip} and N^{strip}=880 MeV are marked by black circles. The lines corresponding to 2^+ - excitation of both vector mesons ($J^\pi=1^-$ - $J^\pi=3^-$, from K^* to K_3^* and from ω to ω_3) are parallel with Δ-excitation and Sternheimer's interval M_q=$m_\Xi/3$ between η-meson and muon, from the kaon to the nucleon and from the nucleon to the Σ-hyperon.

The discussed discreteness of pion and muon masses (17:13:1) with the period δ takes place also in stable intervals in mesons masses. For example, intervals m_{φ}-m_{ω}=m_{ω}-m_{η}=236 MeV and m'_{η}-m_{η}=m_{η}-$m_{\pi}^{\pm}$=409 MeV are close to n=29 and n=50. The second interval (n=50) shown as crossed arrow coincides with $2m_{\pi^o}+m_{\pi}$.

Four additional relations with Sternheimer's parameter M_q=441 MeV were found:

1) Consideration of the possible origin of large mass intervals was connected with the fact that M_q=441 MeV is equal to a half of nucleon "stripped" mass M_N^{strip} ≈880 MeV from lattice calculations. One can add to this value ($2M_q$=$6\Delta M_{\Delta}$) the nucleon Δ - excitation ($2\Delta M_{\Delta}$) for obtaining the corresponding "stripped" mass for Δ-baryon. The resulting estimate $8\Delta M_{\Delta}$=$3M''_q$ of "stripped" mass of Δ-baryon and the above discussed its "initial" mass are both represented as three-fold values of parameters of the parameters M''_q and M_q found independently in other data.

2) Coincidence of $2M_q$ with 2^+ - excitations of both vector mesons (J^{π}=1^--J^{π}=3^-) can be seen in Fig.8. Both lines: from K^* to K_3^* and from ω to ω_3) are going parallel to the nucleon Δ-excitation and Sternheimer's interval.

3) Closeness of τ-lepton mass to $4M_q$ is evident from Fig.8.

4) Both estimates M_q and M''_q of the constituent quarks form ratios with vector boson masses close to the lepton ratio (L=m_mu/m_e). We know that boson masses are parameters of the Standard Model (together with masses of fundamental fermions m_e, m_{μ} etc.). According to Y.Nambu the present state of 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. ... When we discover phenomena which we do not understand, the first thing to do is ... to try to find some empirical regularities among them. The mass problem: a) The fermion masses ...; b) The Higgs sector; c) The hierarchy problem ... with the Standard Model, we have reached the third stage of a three-stage cycle, and we are now at the door step of a new cycle. The mass problem is already an early signal for it" [5].

Small relative downward shift $1.126{\cdot}10^{-3}$ in the muon mass (from the nearby value $13 \times 16m_e$-m_e) is close to the QED radiative correction for electron magnetic moment $\alpha/2\pi$=$1.16{\cdot}10^{-3}$. After a small "correction" of the electron mass m_e^*=$m_e(1-\alpha/2\pi)$ the ratios between m_e^*, the mass splitting of pion δ_{π} and the muon mass become close to the integers, namely m_e^*:δ_{π}:m_{μ}=1:9.000:(207.02=L=9×23=13×16-1) [1]. The ratios M_Z/M_q and M_W/M''_q are close to L and ratios M_q/M''_q and M_Z/M_W are close to 9/8=1.125 (M_Z/M_W=91.188/80.423=1.134) [1]. The ratio between the well-known SM-parameters m_{μ}/M_Z=105.658/91188MeV=$1.159 \cdot 10^{-3}$ is really very close to $\alpha/2\pi$...=$1.159 \cdot 10^{-3}$. These values are shown in the left part of Table 5 while m_e and M_q=$3\Delta M_{\Delta}$ are shown at right. The preliminary value of the Higgs boson mass from the LEP measurements and the top-quark mass are given in the upper part of Table 5 [1].

This report contains findings in nuclear data concerning the common tuning effect (common energy/mass parameters) and dimensionless relations between them. In addition to the discussed empirical relation with the well-known QED correction it was noticed [1] that similar QED correction for small distances (α_Z=1/129 [22] instead of 1/137) also could be considered if the existing uncertainty in the Higgs boson mass will be removed.

Independent argument for a presence of the discussed here tuning effects in particle masses was obtained by R.Frosch [23]. He performed the correlation analysis of 47 values of particle masses and has found that the first candidate for the common period in these masses is the value $3m_e$. It was shown in [24,25] that nucleon masses (m_n, m_p) are shifted downwards relative to the value n=6×17+13 (in units δ=16m_e) corresponding to the Nambu's relation. Such shifts are m_e+162(1) keV and m_e+1455(1) keV while the mass splitting of nucleon δ_N=1293 keV relate to them as 1:8:9 = 162 keV:1293 keV:1455 keV. We see that a direct study of stable nuclear intervals with values integer to 161 keV=D_o (and related to the pion mass, Table 5) could be connected with the results by R.Frosch.

5 Conclusions

Nuclear forces are the result of a process of the spilling out of strong interaction between quarks forming nucleons. The possible involvement of three well-known parameter of the particle physics: the electromagnetic mass differences of nucleon (D_o), pion (about $9m_e$) and lepton (m_e) in nuclear data can be considered in line with the suggestion by S.Devons [4] about fine nuclear effects which reflect nucleon structure and which would be difficult to observe in high energy physics.

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