COMBINED ANALYSIS OF NUCLEAR DATA AND PARTICLE MASSES

S.I. Sukhoruchkin, Z.N. Soroko, M.S. Sukhoruchkina

Petersburg Nuclear Physics Institute named by B.P.Konstantinov of NRC Kurchatov Institute 188300 Gatchina

1. Introduction

Neutron resonance spectroscopy could play an important role in the development of the Standard Model - a modern theory of all interactions [1] except gravitation and dark matter problem. A specific position of scalar and vector field masses among masses of other particles and constituent quarks was considered in [2]. Between masses of these fields (boxed in Table 1, top), other particle masses and stable nuclear intervals a correlation (named fine– and superfine structure) was established. Recently performed analysis [3] of mass spectra of all particles from the compilation PDG–2016 [1] confirmed discussed earlier "tuning effect" in particle masses and relations [4] between masses of nucleons and the electron (CODATA relations [2]).

Presence of stable intervals of 104 MeV and 142 MeV close to masses of the muon and the pion (n=13 and 17 of the CODATA period $\delta = 16m_e$) in the particle mass spectrum was noticed earlier by different authors [5,6]. The value δ=8.176 MeV was connected [5,6] with the proximity of d-quark mass estimate m_d=4.78 MeV [1] and pion charge splitting 4.594 MeV to $9m_e$=4.599 MeV = Δ. Simultaneously, there is a proximity of pions parameters f_π, m_π-m_e and ΔM_Δ=147 MeV (quark interaction in NRCQM, Nonrelativistic Constituent Quark Model) to integers n=16,17,18 of the common period δ. It is shown in [7] that QCD dynamics is based on gluon quark–dressing effect (from the Dyson–Schwinger equations and lattice QCD calculations) and is resulted in the constituent quark mass $M_q \approx 400$ MeV close to the standard estimates of constituent quark masses in NRCQM $M_q = m_\Xi/3$=441 MeV=$3\Delta M_\Delta$ (n=3×18) and $M''_q = m_\rho/2$=388 MeV$\approx 3f_\pi$ (n=3×16). The ratio between masses of two fermions, namely, the electron and constituent quark m_e/M_q=(0.511 MeV/441 MeV)=115.8·10^{-5} is close to the ratio $1/27{\cdot}32 = 115.7 \cdot 10^{-5}$ in the tuning effect and to the QED radiative correction $\alpha/2\pi = 115.9 \cdot 10^{-5}$. V. Belokurov, D. Shirkov and R. Feynman [8,9] suggested that similar factor close to $\alpha/2\pi$ (correction to the electron magnetic moment) is contained also in the electron mass itself.

The fundamental origin of observed tuning effects (including common fine structure in particle masses and in unclear data) is connected with an important role of QCD as SM-component. We observe the fine structure and long–range correlations with m_e, $\Delta = 9m_e$ and $\Delta M_\Delta = 32\Delta$ [6] in nuclear data because the hadronization and mass generation in QCD is a base for the nuclear physics. Intervals of common fine structure in CODATA relations (n=17,18) and in nuclear data (n=13,14-18 [6]) are expressed as:

$$D = \Delta M = n \times 9.5\ keV; \quad n = 13, 14, 16, 17, 18 \qquad (1)$$

The value of the period δ'=9.5 keV=$8\varepsilon'$ is boxed in the central left part of Table 1. Manifestation of this parameter in positions of neutron resonances in light nuclei (top) and in the near-magic nuclei with N=82 (^{141}Ce and ^{142}Pr, center of Table 2 left) and in low-lying excitations of neighbour ^{143}Ce is presented in Table 2 together with the position of resonances at integer values of 1/8 part of the δ' , namely, at integers of the parameter ε'=1.188 keV, found earlier [5,6] in nonstatistical effects in many nuclei.

In the distribution of differences (ΔM) between all accurately known particle masses the grouping effect was found at the muon mass (ΔM=104 eV, 13δ-m_e), the pion mass (ΔM=142 MeV, 17δ+m_e), in regions of the constituent quark mass in NRCQM (ΔM=445-460 MeV) and at the bottom quark mass (ΔM=3959 MeV close to 9M_q=3969 MeV). It allows to represent as a single mass sequence the vector boson masses M_Z=91.19 GeV=13$\delta°$-M_q=L·M_q and M_W=80.38 GeV=$13 \cdot 16 M''_q$, the top quark mass m_t=172 GeV (close to 3×16$\delta°$=169 GeV), and finally, scalar field mass, M_H=125 GeV (close to 18$\delta°$=126 GeV) with the period $\delta°=16M_q=(\alpha/2\pi)^{-1}\delta$. Rapidly increasing number of accurately estimated values of particle masses allows to check CODATA relation with the forthcoming file PDG–2018. Besides nuclear fine structure effects with intervals multiple to 161–170 keV (n=17,18), additional systems of stable intervals corresponding to n=13,14,16 with the same period δ=9.5 keV were found [6]. Simultaneously, in neutron resonance spacing distributions second order effects with the same above mentioned small QED parameter $\alpha/2\pi$ were found as superfine structure with the period δ''=11 eV=$(\alpha/2\pi)^2\delta=(\alpha/2\pi)^3\delta°$. It is shown in Table 1, where above discussed intervals of the tuning effect (starting from NRCQM parameters, line X=0, M=3), stable spacing in particle masses spectrum 104 MeV≈ m_μ and m_π (n=13,17, line X=0, M=1) and corresponding intervals of fine and superfine structures (lines X=1 and 2) are presented as different power X of discussed factor $\alpha/2\pi \approx 1/32 \times 27$ and numbers n=1,13,16,17,18 in the expression n·16m$_e(\alpha/2\pi)^X$M.

Table 1. Representation of parameters of tuning effects in particle masses (top) and nuclear data (bottom) with the expression n·16m$_e(\alpha/2\pi)^X$M and different values of the X–power of QED factor $\alpha/2\pi$ and integers M,n. Boxed are groups of values differing with $\alpha/2\pi$.

X	M	n = 1	n = 13	n = 16	n = 17	n = 18	n = 18·6
-1	3/2			m_t=172.0			
GeV	1	$16M_q=\delta°$	M_Z=91.2	M'_H=115		M_H=126	
	1/2	(m_b-M_q)		M^{L3}=58			
0	1	$16m_e=\delta=8\varepsilon_\circ$	m_μ=106	f_π=130.7	m_π-m_e	ΔM_Δ=147	$2M_q$
MeV	3	NRCQM		M"$_q$=m_ρ/2		M_q=441=ΔE_B	
1	1				kδ-m_n-m_e=	170 = m_e/3	
		CODATA			=161.65		
keV	8				δm_N=1293.3		
1	1	9.5=δ'=8ε'	123	152	Δ^{TF}=161	170 (Sn)	$\varepsilon_o=2m_e$
keV	3				484 (E^*)	512 (Pd)	
	4		492		648 (Pd)	682(Co)	
	6					1023 (Os)	
	8		984	1212	1293 (E^*)	1360 (Te)	
2	1	11=δ''=8ε''	143	176	186 (Nd)		ε'=1188
eV	2				377 Nd)		.
	4,6		570 (Sb)		749 (Br,Sb,Rh)	1205 (Os)*	
	8				1500 (Pd,Hf,Sb,Rh)		
	8×5				7498 (Pd)	M=3	ε''=1.35

* Before recoil correction

2. Fine structure in nuclear excitations

General character of the QCD dynamics is reflected in proximities to QED correction of ratios of fine structure parameters in nuclear data and particle masses to well-known parameters of strong interaction m_π=140 MeV and ΔM_Δ=147 MeV (161 keV/m_π=115·10^{-5} and 170.3 keV/147 MeV=116·10^{-5}). We should mention here three aspects.

1) Position of neutron resonance is a difference between excitation energy and neutron separation energy, hence, now one can assign nonstatistical effects in neutron resonance positions to the common structure in particle masses (CODATA) and nuclear data (n=17,18 of the period 9.5 keV=δ'). This interval δ' was directly observed by M. Ohkubo in the position of strong resonances of near–magic ^{141}Ce [10] (Table 2).

2) Observed by K. Ideno [11] superfine structure in ^{124}Sb with the period 11 eV=δ'' (see Table 1, Fig. 8 in [12]) could serve as a second example of a role of neutron spectroscopy in SM–development due to the fact that a ratio between these parameters δ''/δ'=11 eV/9.5 keV=115.8·10^{-5} is close to $\alpha/2\pi$. In Table 1 (bottom) similar ratios between superfine intervals D=373–570–1501 eV in ^{124}Sb (Fig. 186 in [6]), D=748–1495 eV in ^{104}Rh, D=749 eV in ^{80}Br, D=1497-7498 eV in ^{107}Pd (Fig. 191 [6]), D=757–1509 eV in ^{127,179}Hf, D=186–377 eV in ^{146,149}Nd (Fig. 192 [6]), D=1205 eV in ^{187,188}Os (Fig. 193 [6]), and corresponding stable fine structure excitations in the same or neighbour nuclei are presented. Such relation could provide an indirect confirmation of QED factor $\alpha/2\pi$.

Table 2. Comparison of positions and spacing in light and near–magic nuclei with the integer values of the parameter of the fine structure $\varepsilon' = \delta'/8 = 1.188$ keV [6].
Top: Positions E'_n of strong neutron resonances in light and magic nuclei and the periodicity in spacing distributions in resonances of ^{61}Ni (top right).
Center: Values E_n in nuclei with N=83=82+1, maxima in spacing distributions of ^{141}Ce.
Bottom left: Positions of strong neutron resonances in isotopes with Z=35–39 are compared with integer number of the period ε'=1.188 keV=9.505 keV/8 found in positions of strong resonances in Z=57–59, N=83 nuclei (center). *Bottom right:* Excitation energies E^* of ^{143}Ce.

Nucl.	Ca-Ni	^{61}Ni	^{61}Ni	^{61}Ni	^{61}Ni	^{61}Ni
E_n, l_n=0, D(keV)	18.8	4.8	9.3	14.1	19.0	24.7
k(ε')	16	4	8	12	16	20
k×ε'	19.0	4.8	9.6	14.4	19.0	24.7
Nucl.	^{141}Ce	^{141}Ce	^{142}Pr	^{141}Ce	^{141}Ce	^{141}Ce
J_i^π	1/2$^+$	1/2$^+$	(5/2$^-$)			
Γ_n^o,meV	660*	3060*	160	D	D	D
E_n	9.573	21.570	9.598	21.7	43.1	86.2
E^*,E'_n	9.505	21.418	9.530			
m(8ε')	1	9/4	1	9/4	9/2	9
m×8ε'	9.504	21.384	9.504	21.4	42.5	85
Nucl.	^{140}La	^{80}Br	^{82}Br	^{86}Rb	^{143}Ce	J_o^π=3/2$^-$
J_i^π	3$^+$	l_n=0	l_n=0	l_n=0	7/2$^-$	5/2$^-$
Γ_n^o,meV	54	72.0	120	159	E^*	E^*
E_n	1.179	1.201	1.209	2.398		
E^*,E'_n	1.170	1.186	1.194	2.370	18.9	42.3
m(8ε')	1/8	1	1	2	2	9/2
m×8ε'	1.188	1.188	1.188	2376	19.0	42.77

In Fig. 1 and Table 3, new results of fine structure analysis in recently published data are presented. Boxed are excitations in light nuclei which belong to fine structure with n=17 ($E^{*}=\delta m_N$ etc. [12]). Such excitations in ^{59}Co, ^{41}K and ^{116}Sn were noticed by O.I. Sumbayev [13] in data from γ-ray compilation [14]. Presence of the fine and superfine structures simultaneously in low-lying excitations and in neutron resonances was found in the regions around N=50, Z=51 and Z=72 (Hf, Os). Proximity of intervals of both structures in different nuclei could be assigned to meson exchange dynamics [6,15].

Neutron resonances correspond to a part of nuclear excitation spectra. In compilation ENSDF appearance of neutron resonances in the spectra of states can be seen as the groping effect. Such groupings were found by S.L. Sakharov [16] (periodicity in positions of these groupings). Results are similar to the correlation noticed earlier in [5].

Returning to the check of CODATA with files of nuclear data (CRF, NRF, MDF), we should notice that combined analysis of these files is important for development of truly microscopic models based on QCD. Quantum numbers of nuclear states should be measured. This time most of neutron resonances have uncertain spin/parity assignment. For example, in new data for excitations in near-magic ^{57}Ni spacing distributions (shown in Fig. 1) could be determined only for groups of states (see partial distributions which contain maxima at D=342 keV=36δ', of low-lying levels), 510 keV=3×18δ' (negative parity levels), 481–510 keV with small $J < 9/2$ and 680 keV (all positive parity levels).

Marked values in Table 3 [6] belong to the discussed system k(m_e/3) or k(δm_N/8).

Table 3. Excitations (in keV) in nuclei N=21,22 (top), N=28,27 and the period of 161 keV.

(Z-14)/2	3		2	1	1	1	1	0	0
^{A}Z	^{41}Ca		^{39}Ar	^{37}S	^{38}S	^{33}S	^{43}S	^{32}Si	^{35}Si
E^{*}	0.0	1943	1267	646.2	1292	322	320.7	1942	973.9
$2J^{\pi}$	7^-	3^-	3^-	3^-	2^+	D	7^-	2^+	(3^+)
k$\frac{\delta m_N}{8}$	0.0	1941	1293	646	1293	322	322	1941	971
^{A}Z	^{53}Ni $2J_o$=7-			^{58}Ni	^{59}Ni	^{61}Ni	^{53}Co	^{59}Co	
E^{*}	320(3)	1292*	1456*	1454.2	339.4	1454.8	646.2*	1291.6)	1459
$2J^{\pi}$	(5^-)	(3^-)	(11^-)	2^+	3^-–5^-	7^-	7^-	3^-	11^-
k$\frac{\delta m_N}{8}$	322	1293	1454	1454	322	1454	647	1293	1454

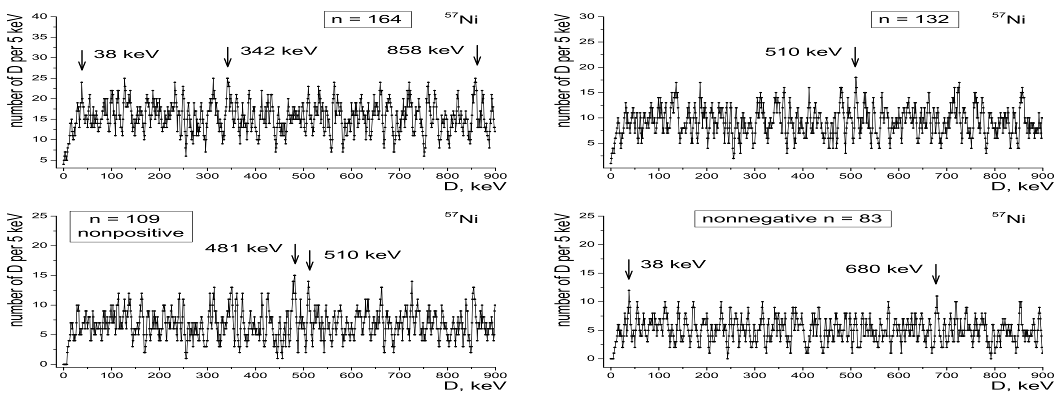

Fig. 1. *Top:* Spacing distribution in all levels of ^{57}Ni (*at left*) and in negative parity levels. *Bottom:* The same for negative parity levels with small spins and for nonnegative parity levels.

3. Analysis of particle masses in PDG–2016 file

In Tables 4–6, a continuation of the analysis [3] of particle masses from PDG–2016 [1] is presented. Table 7 contains new file PDG–2017. Values are given in the same order as they appear in Summary Tables and marked according to their uncertainty ΔM (as it was done in [6,12]. In this work, distributions for averaging intervals Δ=5 MeV and 9 MeV (Tables 4–6) were used.

Table 4. Particle masses [4] (in MeV) known with the uncertainty less than 6 MeV (intervals 193–1304 MeV).

	Particle		m$_\text{i}$	Δ	193	584	794 Δ=9	932	1092	1304
1	leptons	electron	0.0							
	μ		105.658					931 (13)		1303 (1)
	τ		1776.82		191 (11)	584 (4)	792 (18)			1304 (12)
2	Unflav.	mesons								
	$\pi^{\pm}$	$1^-(0^-)$	139.570						1090 (1)	
	η	$0^+(0^{-+})$	547.86							1306 (2)
	$\eta'(958)$	$0^+(0^{-+})$	957.78							
	$\phi(1020)$	$0^-(1^{--})$	1019.46						1093 (4)	
	$b_1(1235)$*	$1^+(1^{+-})$	1229.5	3.2			796 (2)		1090 (1)	1306 (4)
	$f_2(1270)$*	$0^+(2^{++})$	1275.5	0.8						1302 (6)
	$f_1(1285)$	$0^+(1^{++})$	1282.0	0.5	194 (2)	583 (6)				
	$a_2(1320)$	$1^-(2^{++}$	1318.3	0.5			794 (4)	934 (5)		
	$\eta(1405)$*	$0^+(0^{--})$	1408.8	1.8		587 (8)				1303 (1)
	$f_1(1420)$*	$0^+(1^{++})$	1426.4	0.9	191 (4)	584 (10)		933 (2)	1092 (7)	
	$\eta(1475)$**	$0^+(0^{-+})$	1476	4	194 (2,5)	584 (1)				
	$f'_2(1525)$**	$0^+(2^{++})$	1525	5		585 (2)	793 (7)	934 (9)		
	$\pi_1(1600)$**	$1^-(1^{-+})$	1662	8	192 (7)		794 (8,9)	930 (11)		1306 (10)
	$\eta_2(1645)$**	$0^+(0^{-+})$	1617	5	191 (3,4)					
	$\omega_3(1670)$**	$0^-(3^{--})$	1667	4	191 (5)	585 (11)	794 (10,11)			
	$\pi_2(1670)$*	$1^-(2^{-+})$	1672.2	3.0	192 (7)		793 (12)		1094 (8)	
	$\rho_3(1690)$*	$1^+(3^{--})$	1688.8	2.1			797 (1)			
	$f_0(1710)$**	$0^+(0^{++})$	1723	6	191 (6)		795 (15)			
	$\phi_3(1850)$**	$0^-(3^{--})$	1854	7	192 (7,11)	582 (5)	791 (19)			1306 (2)
	$a_4(2040)$**	$1^-(4^{++}$	1995	8		587 (8,13)	797 (21)			
3	strange	mesons								
	$K^{\pm}$	$1/2(0^-)$	493.677					932 (1,2)		
	$K^*(892)^{*\pm}$	$1/2(1^-)$	891.66			584 (1)	797 (1)	931 (3)		
	$K_1(1270)$**	$1/2(1^+)$	1272	7		582 (5)				1306 (5)
	$K_1(1400)$**	$1/2(1^+)$	1403	7	,					1305 (8)
	$K^*_2(1430)^{\pm *}$	$1/2(2^+)$	1425.6	1.5	191 (3)	585 (9)		932 (1)	1093 (6)	
	$K_2(1770$**	$1/2(2^-)$	1773	8			796 (16)			
	$K^*_3(1780)$**	$1/2(3^-)$	1776	7	192 (10)	583 (3)	793 (17)	932 (12)		1304 (11)
	$K^*_4(2045)$**	$1/2(4^+)$	2045	9	191 (12)	583 (15)				
4	charmed	mesons								
	D°	$1/2(0^-)$	1864.83		192 (8,9)	583 (6)			1090 (2)	
	$D^{\pm}$	$1/2(0^-)$	1869.58			584 (12)		930 (4)	1094 (3)	
	$D^*(2010)^{\pm}$	$1/2(1^-)$	2010.28			585 (9,10,14)				
	$D_1(2420)^{\circ}$	$1/2(1^+)$	2420.8	0.5					1090 (10)	1305 (3)
	$D^*_2(2460)^{\pm *}$	$1/2(2^+)$	2465.4	1.3			798 (11,12,13)	934(10)	1091 (11)	
5	charmed,	strange	mesons							
	$D^{\pm}_s$	$0^+(0^-)$	1968.27		192 (10,11)	586 (7)	798 (20)			
	$D^{*\pm}_s$	$0(?^?)$	2112.1	0.4		583 (16)	797 (3,4,5,23)		1093 (4)	1303 (13)
	$D^*_{so}(2317)^{\pm}$	$0(0^+)$	2317.7	0.6			794 (6,7)	934 (7)		
	$D_{s1}(2460)^{\pm}$	$0(1^+)$	2459.5	0.6			798 (9,10)	934 (9)		
	$D_{s1}(2536)^{\pm}$	$0(1^+)$	2535.10							1306 (4)
	$D^*_{s2}(2573)$*	$0(2^+)$	2569.1	0.8			794 (16,17,18)			1303 (17)
	$D^*_{s1}(2700)^{\pm *}$	$0(1^-)$	2708.3	3.4	190 (14)			932 (12,13,16)		1304 (8,9)
6	bottom	mesons								
	$B^{\pm}$	$1/2(0^-)$	5279.31					932 (19)		
	$B_1(5721)^{+ *}$	$1/2(1^+)$	5725.9	2.7	194 (20)					1305 (18)
7	bottom	strange	mesons							
	B°_s	$0(0^-)$	5366.82			582 (20)				
9	$c\bar{c}$“	mesons								
	$\eta_c(1S)$	$0^+(0^{-+})$	2983.4	0.5	191 (16)		790 (26)			
	$J/\psi(1S)$	$0^-(1^{--})$	3096.90		191 (17)		790 (28)			
	$\chi_{c0}(1P)$	$0^+(0^{++})$	3414.75					932 (18)		1303 (13)
	$\chi_{c1}(1P)$	$0^+(1^{++})$	3510.66					933 (14)	1090 (10)	

Table 4. Continued.

	Particle		m_i	Δ	193	584	794 Δ=9	932	1092	1304
	$h_c(1P)$	$?^?(0^{+-})$	3525.38			586(18)		933(15)		
	$\chi_{c2}(1P)$	$0^+(2^{++})$	3556.20				790(25,29)		1091(11)	1304 (14)
	$\eta_c(2S)$*	$0^+(0^{-+})$	3639.2	1.2		584(19)		931(16)		
	$\psi(2S)$	$0^-(1^{--})$	3686.10						1094(12)	
	$\psi(3770)$	$0^-(1^{--})$	3773.13				790(26)			1302 (15)
	$\psi(3823)$*	$?^?(2^{--})$	3822.2	1.2						1304 (16)
	$X(3872)$	$0^+(1^{++})$	3871.69				792(27)	932(17)		1303 (17)
	$X(3900)$*	$1^+(1^{+-})$	3886.6	2.4			790(28)			
	$X(4140)$*	$0^+(??+)$	4146.9	3.1					1092(13)	
	$X(4140)$*	$0^+(??+)$	4146.9	3.1					1092(13)	
	$X(4360)$**	$?^?(1--)$	4346.9	6			791(29)	932(18,19)		
	$\psi(4415)$**	$0^-(1--)$	4421	4						1305 (18)
	$X(4660)$**	$?^?(1--)$	4643	9	193(18)					1306 (19)
10	$b\bar{b}$	mesons								
	$\eta_b(1S)$*	$0^+(0-+)$	9399.0	2.3						
	$\Upsilon(1S)$	$0^-(1--)$	9460.30				795(30)			
	$\Upsilon(1D)$*	$0^-(2--)$	10163.7	1.4	192(21)					
	$\chi_{b0}(2P)$	$0^+(0++)$	10232.5	0.4		584(21)				
	$\chi_{b1}(2P)$	$0^+(1++)$	10255.46				795(30)			
	$\Upsilon(3S)$	$0^-(1--)$	10355.2	0.5	192(21)					
	$X(10610)^{\pm}$*	$1^+(1^+)$	10607.2	2.0		584(21)				
11		baryons								
	n	$1/2(1/2^+)$	939.5654			585(2)		930(4)		
	Λ	$0(1/2^+)$	1115.683							1305 (3)
	$\Lambda(1405)1/2^-$*	$0(1/2^-)$	1405.1	1.3						1303 (9)
	$\Lambda(1520)3/2^-$*	$0(3/2^-)$	1519.5	1.0			798(6)	934(8)		
	Σ°	$1(1/2^+)$	1192.642		191(1)	584(3,4)			1094(5)	
	$\Sigma(1385)^\circ$*	$1(3/2^+)$	1383.7	1.0	191(1)	586(7)		934(7)		
	Ξ°	$1/2(1/2^+)$	1314.86	0.20			797(3)			
	Ξ^-	$1/2(1/2^+)$	1321.71	0.07			797(5)	930(6)		1306 (7)
	$\Xi(1530)3/2^{+\circ}$	$1/2(3/2^+)$	1531.80	0.32	191(6)			945(10)		
	$\Xi(1820)3/2^-$	$1/2(3/2^-)$**	1823	5				931(3)		
	$\Xi(2030)$**	$1/2(\geq 3/2^?)$	2025	5			786(2,22)			
	Ω^-	$0(3/2^+)$	1673.45		191(9)		794(13,14)		1092(9)	
	$\Omega(2250)^-$**	$0(?^?)$	2252	9		585(11)		932(5,6)		1304 (14)
12	charmed	baryons								
	Λ_c^+	$0(1/2^+$	2286.46				793(24)		1094(5)	
	$\Lambda_c(2595)^+$	$0(1/2^-)$	2592.25			583(14)		930(11,15)	1094(12)	
	$\Lambda_c(2625)^+$	$0(3/2^-)$	2628.11		191(15)	583(15)				1306 (7)
	$\Lambda_c(2940^+)$*	$0(5/2^+)$	2939.3	1.5		586(18)		932(17)		
	$\Sigma_c(2455)^\circ$	$1(1/2^+)$	2453.75		192(13)	584(12)	792(8)	934(8)		
	$\Sigma_c(2520)^\circ$	$1(3/2^+)$	2518.48		190(14)		795(15)		1092(6,7)	1304 (16)
	$\Sigma_c(2800)^\circ$**	$1(3/2^+)$	2906	7	190(17)		794(23)			
	Ξ_c°	$1/2(1/2^+)$	2470.85			584(17)	797(14)			1302 (15)
	$\Xi_c'^\circ$*	$1/2(1/2^+)$	2577.9	2.9		583(13)		933(14)		1304 (5,6)
	$\Xi_c(2645)^\circ$	$1/2(3/2^+)$	2645.9	0.5	192(13)		792(19)			
	$\Xi_c(2790)^\circ$*	$1/2(1/2^-)$	2791.9	3.3	192(16)		797(21)			
	$\Xi_c(2815)^\circ$*	$1/2(3/2^-)$	2819.6	1.2	191(15)		795(22)			
	$\Xi_c(2970)^\circ$*	$1/2(?^?)$	2968.0	2.6						1306 (10)
	$\Xi_c(3055)$*	$1/2(?^?)$	3055.1	1.7		584(17,19)			1092 (13)	
	$\Xi_c(3080)^\circ$*	$1/2(?^?)$	3079.9	1.4			794(24,27)			1304 (11,12)
	Ω_c°*	$0(1/2^+)$	2695.2	1.7		583(16)				
	$\Omega_c(2770)^\circ$*	$0(3/2^+)$	2765.9	2.0			798(20,25)		1092 (8,9)	
13	bottom	baryons								
	Λ_b°	$0(1/2^+)$	5619.51		192(19)					
	$\Lambda_b(5920)^\circ$	$0(3/2^-)$	5919.81		194(20)					
	Σ_b^+*	$1(1/2^+)$	5811.3	1.9	192(19)					
	$\Xi_b(5945)^\circ$*	$1/2(3/2^+)$	5948.9	1.6		582(20)				1306 (19)
	$P_c(4450)^+$*		4449.8	3.0	193(18)					

Table 5. Particle masses [4] (in MeV) known with the uncertainty less than 6 MeV (intervals 336–3371 MeV).

	Particle		m_i	Δ	336	447	460	1673	1688	3371
1	leptons	el., ν	0.0					1673 (1,2)	1688 (1)	
	μ		105.658					1673 (3,4)		
	τ		1776.82		336 (22)		460 (7,9)	1673 (4)		

Table 5. Continued.

	Particle		$\mathrm{m_i}$	336	447	460	1673	1688	3371
2	Unflav.	mesons							
	$\pi^{\pm}$	$1^-(0^-)$	139.570						3371(1)
	η	$0^+(0^{-+})$	547.86						
	$\rho(770)$	$1^+(1^{--})$	775.26	336(1)				1688(2,3)	3371(3)
	$\omega(782)$	$0^-(1^{--})$	782.65	336(2)	447(2)		1673(5,6)	1688(4)	
	$\eta'(958)$	$0^+(0^{-+})$	957.78	336(6)	447(4,5,6)	460(1)	1673(8)	1688(7)	3371(2)
	$\phi(1020)$	$0^-(1^{--})$	1019.46			460(3)	1673(9)	1688(8)	
	$b_1(1235)$*	$1^+(1^{+-})$	1229.5	336(3)	447(2,7,8)	460(4)	1673(11)		
	$f_2(1270)$*	$0^+(2^{++})$	1275.5	336(5)	447(10)			1688(10)	3371(5)
	$f_1(1285)$	$0^+(1^{++})$	1282.0	336(9)				1688(11)	
	$\eta(1295)$**	$0^+(0^{-+})$	1294	336(6)			1673(12)	1688(1)	
	$a_2(1320)$	$1^-(2^{++}$	1318.3			460(8,9)			
	$\eta(1405)$*	$0^+(0^{--})$	1408.8		447(6,14)	460(13,14)	1673(17)	1688(14)	
	$f_1(1420)$*	$0^+(1^{++})$	1426.4		447(16)		1673(19)		
	$\eta(1475)$**	$0^+(0^{-+})$	1476			460(3)			
	$f_0(1500)$**	$0^+(0^{++})$	1504			460(15)			
	$f_2'(1525)$**	$0^+(2^{++})$	1525	336(7,13)	447(18)				
	$\pi_1(1600)$**	$1^-(1^{-+})$	1662	336(10,16)	447(19)				
	$\eta_2(1645)$**	$0^+(0^{-+})$	1617	336(9)					
	$\omega_3(1670)$**	$0^-(3^{--})$	1667		447(20)				
	$\pi_2(1670)$*	$1^-(2^{-+})$	1672.2	336(17)	447(7)		1673(1)		
	$\rho_3(1690)$*	$1^+(3^{--})$	1688.8	336(19)		460(4)		1688(1)	
	$f_0(1710)$**	$0^+(0^{++})$	1723	336(11)	447(9,10)			1688(15)	
	$\phi_3(1850)$**	$0^-(3^{--})$	1854	336(12)	447(12,13,14)	460(18)	1673(20)		
	$a_4(2040)$**	$1^-(4^{++}$	1995	336(16)		460(16,19,21)		1688(19)	3371(6)
3	strange	mesons							
	$K^{\pm}$	$1/2(0^-)$	493.677		447(1)	460(1)			
	$K^*(892)^{*\pm}$	$1/2(1^-)$	891.66	336(3)			1673(7)	1688(5)	
	$K_1(1270)$**	$1/2(1^+)$	1272	336(4)	447(9)				3371(4)
	$K_1(1400)$**	$1/2(1^+)$	1403		447(4,12)	460(2,10)	1673(15)		
	$K_2^*(1430)^{\pm *}$	$1/2(2^+)$	1425.6		447(15)		1673(12)		
	$K_2(1770$**	$1/2(2^-)$	1773	336(20)	447(11)	460(5)			
	$K_3^*(1780)$**	$1/2(3^-)$	1776	336(21)		460(6,8)	1673(3)		
	$K_4^*(2045)$**	$1/2(4^+)$	2045						3371(7)
4	charmed	mesons							
	D°	$1/2(0^-)$	1864.83	336(13,14)		460(10,11,13)		1688(17)	
	$D^{\pm}$	$1/2(0^-)$	1869.58	336(15)	447(15,16,21)	460(12,14)		1688(18)	
	$D^*(2010)^{\pm}$	$1/2(1^-)$	2010.28	336(17,18)	447(22,23)	460(21)	1673(22)		
	$D_1(2420)^{\circ}$	$1/2(1^+)$	2420.8			460(24)			3371(9)
	$D_2^*(2460)^{\pm *}$	$1/2(2^+)$	2465.4					1688(3)	3371(13,14)
5	charmed,	strange	mesons						
	$D_s^{\pm}$	$0^+(0^-)$	1968.27		447(17,18)	460(15)	1673(12)		
	$D_s^{*\pm}$	$0(?^?)$	2112.1	336(20,21,22)	447(19,20)	460(22)			
	$D_{s\circ}^*(2317)^{\pm}$	$0(0^+)$	2317.7		447(21,26)	460(18)			
	$D_{s1}(2460)^{\pm}$	$0(1^+)$	2459.5	336(25)	447(23,27)	460(20)	1673(6)	1688(2,20)	3371(11,12)
	$D_{s1}(2536)^{\pm}$	$0(1^+)$	2535.10		447(29)				
	$D_{s2}^*(2573)$*	$0(2^+)$	2569.1	336(26)		460(22)	1673(7)		
	$D_{s1}^*(2700)^{\pm *}$	$0(1^-)$	2708.3			460(23)		1688(8)	
6	bottom	mesons							
	$B^{\pm}$	$1/2(0^-)$	5279.31	336(32)					
	B^*	$1/2(1^-)$	5324.65					1688(22)	
	$B_1(5721)^{+*}$	$1/2(1^+)$	5725.9		447(33)			1688(24)	
	$B_2^*(5747)^{+*}$	$1/2(2^+)$	5737.2			460(31)			
	$B_J(5970)^+$	$1/1(?^?)$**	5964						3371(17)
7	bottom	strange	mesons						
	B_s°	$0(0^-)$	5366.82		447(34)	460(32)			3371(6)
	B_s^{*}*	$0(1^-)$	5415.4						3371(7)
	$B_{s1}(5830)^{\circ}$	$0(1^+)$	5828.63	447(35)	460(32)			3371(10,11)	
	$B_{s2}^*(5640)^{\circ}$	$0(2^+)$	5839.84					3371(14,15)	
8	bottom	charmed	mesons						
	B_c^{*}*	$0(0^-)$	6275.1	336(34)	447(35,36)	460(33)			3371(18)
9	$c\bar{c}$"	mesons							
	$\eta_c(1S)$	$0^+(0^{-+})$	2983.4	336(28)	447(29)		1673(13)	1688(12)	
	$J/\psi(1S)$	$0^-(1^{--})$	3096.90		447(30)	460(27)	1673(18,19)	1688 (13.14)	
	$\chi_{c0}(1P)$	$0^+(0^{++})$	3414.75	336(29)	447(31)	460(28)		1688(15)	
	$\chi_{c1}(1P)$	$0^+(1^{++})$	3510.66			460(26)		1688(16)	3371(1)
	$h_c(1P)$	$?^?(0^{+-})$	3525.38		447(32)		1673(20)		

Table 5. Continued.

	Particle		m_i	336	447	460	1673	1688	3371
	$\chi_{c2}(1P)$	$0^+(2^{++})$	3556.20			460(27)		1688(17,18)	
	$\eta_c(2S)$*	$0^+(0^{-+})$	3639.2				1673(21)	1688(22)	
	$\psi(2S)$	$0^-(1^{--})$	3686.10	336(30)		460(29)	1673(26)	1688(19)	
	$X(3872)$	$0^+(1^{++})$	3871.69			460(28)			
	$X(3900)$*	$1^+(1^{+-})$	3886.6			460(30)			
	$X(3915)$*	$0^+(?^{++})$	3918.4	336(31)					3371(2)
	$\chi_{c2}(1P)$*	$0^+(2^{++})$	3927.2				1673(23)	1688(23)	
	$X(4020)$*	$1(?^?)$	4024.1	336(30)					
	$\psi(4040)$**	$0^-(1--)$	4039					1688(24)	
	$X(4140)$*	$0^+(??+)$	4146.9			460(29)	1673(24)	1688(20,25)	3371(3)
	$\psi(4160)$**	$0^-(1--)$	4191				1673(25)		
	$X(4260)$**	$?^?(1--)$	4251	336(31)			1673(28,26)	1688(26)	
	$X(4360)$**	$?^?(1--)$	4346.9			460(30)			
	$X(4660)$**	$?^?(1--)$	4643				1673(27)		3371(4,5)
10	$b\bar{b}$	mesons							
	$\eta_b(1S)$*	$0^+(0-+)$	9399.0			460(34)			
	$\chi_{b0}(1P)$	$0^+(0++)$	9859.44			460(34)			
	$\chi_{b1}(1P)$	$0^+(0++)$	9892.78	336(35)		460(35)			
	$h_b(1P)$*	$?^?(1+-)$	9899.3	336(36)		460(36)			
	$\chi_{b2}(1P)$	$0^+(2++)$	9912.21		447(37)				
	$\Upsilon(2S)$	$0^-(1--)$	10023.26	336(37)					
	$\Upsilon(1D)$*	$0^-(2--)$	10163.7		447(38)				
	$\chi_{b0}(2P)$	$0^+(0++)$	10232.5	336(35,36)					
	$\chi_{b2}(2P)$	$0^-(2+-)$	10268.65	336(38)					
	$\Upsilon(3S)$	$0^-(1--)$	10355.2	336(37)	447(37)	460(35,36)			
10	$X(10610)^{\pm}$*	$1^+(1^+)$	10607.2	336(38)	447(38)				
11		baryons							
	n	$1/2(1/2^+)$	939.5654	336(4,5)	447(1,3)	460(2)		1688(6)	
	Λ	$0(1/2^+)$	1115.683	336(1,2)			1673(10)		
	$\Lambda(1405)1/2^-$*	$0(1/2^-)$	1405.1		447(5,13)	460(11,12)	1673(16)	1688(13)	
	$\Lambda(1520)3/2^-$*	$0(3/2^-)$	1519.5	336(12)	447(17)				
	Σ°	$1(1/2^+)$	1192.642	336(7,8)				1688(9)	
	$\Sigma(1385)^\circ$*	$1(3/2^+)$	1383.7	336(11)	447(3)		1673(14)		
	Ξ°	$1/2(1/2^+)$	1314.86			460(5,6,7)	1673(13)		
	Ξ^-	$1/2(1/2^+)$	1321.71	336(10)	447(11)				
	$\Xi(1530)3/2^{+\circ}$	$1/2(3/2^+)$	1531.80	336(8,14,15)		460(16)			
	$\Xi(1820)3/2^-$	$1/2(3/2^-)$**	1823			460(17)		1688(16)	
	$\Xi(2030)$**	$1/2(\geq 3/2^?)$	2025	336(19)	447(24)				
	Ω^-	$0(3/2^+)$	1673.45	336(18)	447(8)		1673(2)		
	$\Omega(2250)^-$**	$0(?^?)$	2252	336(23)	447(25)	460(21)	1673(23)		3371(8)
12	charmed	baryons							
	Λ_c^+	$0(1/2^+$	2286.46			460(17)			
	$\Lambda_c(2595)^+$	$0(1/2^-)$	2592.25	336(23)		460(25)			3371(17)
	$\Lambda_c(2625)^+$	$0(3/2^-)$	2628.11	336(27)			1673(8)	1688(6)	
	$\Lambda_c(2880^+)$	$0(5/2^+)$	2881.53					1688(9)	
	$\Sigma_c(2455)^\circ$	$1(1/2^+)$	2453.75	336(24)	447(22)	460(19)	1673(5)		3371(10)
	$\Sigma_c(2520)^\circ$	$1(3/2^+)$	2518.48		447(28)		1673(12)		
	$\Sigma_c(2800)^\circ$**	$1(3/2^+)$	2906	336(26)	447(27)		1673(11)		3371(18)
	Ξ_c°	$1/2(1/2^+)$	2470.85		447(24)	460(21)	1673(24)	1688(4)	3371(15)
	$\Xi_c'^\circ$*	$1/2(1/2^+)$	2577.9				1673(26)	1688 (5)	3371(16)
	$\Xi_c(2645)^\circ$	$1/2(3/2^+)$	2645.9	336(28)	447(30)			1688(7)	
	$\Xi_c(2790)^\circ$*	$1/2(1/2^-)$	2791.9	336(24,25)			1673(10)		
	$\Xi_c(2970)^\circ$*	$1/2(?^?)$	2968.0	336(27)	447(28,31)		1673(12,27)	1688(10,11)	
	$\Xi_c(3055)$*	$1/2(?^?)$	3055.1			460(25,26)	1673(14)		
	$\Xi_c(3080)^\circ$*	$1/2(?^?)$	3079.9	336(29)	447(32)		1673(15,16,17)		
	Ω_c°*	$0(1/2^+)$	2695.2		447(25)		1673(9)		
	$\Omega_c(2770)^\circ$*	$0(3/2^+)$	2765.9		447(26)			1688(21)	
13	bottom	baryons							
	Λ_b°	$0(1/2^+)$	5619.51	336(32,33)				1688(23)	3371(8)
	Σ_b^+*	$1(1/2^+)$	5811.3		447(34)	460(33)			
	Σ_b^{*+}*	$1(3/2^+)$	5832.1		447(36)			1688(25)	3371(12,13)
	Ξ_b°	$1/2(1/2^+)$	5791.9						3371(9)
	$\Xi_b'(5935)^-$	$1/2(1/2^+)$	5935.02	336(34)				1688(26)	
	$\Xi_b(5945)^\circ$*	$1/2(3/2^+)$	5948.9						3371(16)
	$\Xi_b^*(5955)^-$	$1/2(1/2^+)$	5955.33	336(33)					
14	exotic	baryons							
	$P_c(4450)^+$*		4449.8					1688(21)	

Table 6. Particle masses [4] (in MeV) known with the uncertainty less than 6 MeV (intervals 4425–3959 MeV).

	Particle		m_i	Δ	4425	4640	3943	4406	4052	3959
1	leptons	el., ν	0.0		4425(1)	4640(1)				
	μ		105.658							
	τ		1776.82						4052(13,14)	3960(11)
2	Unflav.	mesons								
	$\pi^{\pm}$	$1^-(0^-)$	139.570						4052(1)	
	η	$0^+(0^{-+})$	547.86							
	$\rho(770)$	$1^+(1^{--})$	775.26			4640(2)				
	$\eta'(958)$	$0^+(0^{-+})$	957.78					4406(1)		
	$b_1(1235)$*	$1^+(1^{+-})$	1229.5	3.2					4052(2)	
	$f_2(1270)$*	$0^+(2^{++})$	1275.5	0.8		4640(6,7)			4052(4)	
	$f_1(1285)$	$0^+(1^{++})$	1282.0	0.5		4640(8)				
	$\eta(1295)$**	$0^+(0^{-+})$	1294	4		4640(9)				
	$a_2(1320)$	$1^-(2^{++}$	1318.3	0.5		4640(11)		4406(2)	4052(6)	3960(3)
	$\eta(1405)$*	$0^+(0^{--})$	1408.8	1.8	4425(10)	4640(15)		4406(7)		3960(7)
	$f_1(1420)$*	$0^+(1^{++})$	1426.4	0.9			3940(3)	4406(10,11)		
	$\eta(1475)$**	$0^+(0^{-+})$	1476	4			3939(4)			
	$f_0(1500)$**	$0^+(0^{++})$	1504	6				4406(12)		
	$f_2'(1525)$**	$0^+(2^{++})$	1525	5	4425(12)			4406(13)		
	$\pi_1(1600)$**	$1^-(1^{-+})$	1662	8						3960(1)
	$\eta_2(1645)$**	$0^+(0^{-+})$	1617	5	4425(14)					
	$\pi_2(1670)$*	$1^-(2^{-+})$	1672.2	3.0			3947(5)		4052(7)	
	$\rho_3(1690)$*	$1^+(3^{--})$	1688.8	2.1					4052(9)	
	$\phi_3(1850)$**	$0^-(3^{--})$	1854	7	4425(15)					3960(12)
	$a_4(2040)$**	$1^-(4^{++}$	1995	8			3940(10)		4052(17)	3960(16)
3	strange	mesons								
	$K^{\pm}$	$1/2(0^-)$	493.677							3960(1)
	$K_1(1270)$**	$1/2(1^+)$	1272	7		4640(5)			4052(3)	
	$K_1(1400)$**	$1/2(1^+)$	1403	7	4425(6,7)	4640(13)		4406(5)		3960 (5)
	$K_2^*(1430)^{\pm}$*	$1/2(2^+)$	1425.6	1.5			3941(2)	4406(8,9)		
	$K_2(1770$**	$1/2(2^-)$	1773	8					4052(10)	3960(9)
4	charmed	mesons								
	D°	$1/2(0^-)$	1864.83				3046(7)	4406(15)	4052(15)	3960(13)
	$D^{\pm}$	$1/2(0^-)$	1869.58				3942(8)	4406(16)	4052(16)	3960(14,15)
	$D^*(2010)^{\pm}$	$1/2(1^-)$	2010.28				3943(11,12)			
5	charmed,	strange	mesons							
	$D_s^{\pm}$	$0^+(0^-)$	1968.27				3944(9)			
	$D_{s1}^*(2700)^{\pm}$*	$0(1^-)$	2708.3	3.4						
6	bottom	mesons								
	$B^{\pm}$	$1/2(0^-)$	5279.31						4052(2)	3960(2)
	B^*	$1/2(1^-)$	5324.65				3941(1)		4052(3,4)	
	$B_1(5721)^+$*	$1/2(1^+)$	5725.9	2.7				4406(2,3)	4052(7,8)	
	$B_2^*(5747)^+$*	$1/2(2^+)$	5737.2	0.7	4425(4,16)				4052(9)	3960(9,10,11)
	$B_J(5970)^+$	$1/1(?^?)$**	5964	5		4640(12,17)	3939(13)			
7	bottom	strange	mesons							
	B_s°	$0(0^-)$	5366.82		4425(2)		3941(2,3)	4406(1)	4052(5,6)	3960(5,6,7)
	B_s^**	$0(1^-)$	5415.4	1.5		4640(2)	3939 (4)			
	$B_{s1}(5830)^{\circ}$	$0(1^+)$	5828.63		4425(6,8,18)	4640(1)		(8,10,18)	4052(10,11,13)	3960(13,14)
	$B_{s2}^*(5640)^{\circ}$	$0(2^+)$	5839.84		4425(20)				4052(19)	
8	bottom	charmed	mesons							
	B_c^**	$0(0^-)$	6275.1	1.0	4425(15)			4406(15,16)		3960(17,22)
9	$c\bar{c}$“	mesons								
	$\psi(4160)$**	$0^-(1--)$	4191	5					4052(1)	
	$\psi(4415)$**	$0^-(1--)$	4421	4	4425(1)					
	$X(4660)$**	$?^?(1--)$	4643	9		4640(1)				
10	$b\bar{b}$	mesons								
	$\chi_{b0}(1P)$	$0^+(0++)$	9859.44				3943(14,15)		4052(18)	
	$\chi_{b1}(1P)$	$0^+(0++)$	9892.78				3944(16)		4052(19)	3960(18)
	$h_b(1P)$*	$?^?(1+-)$	9899.3	0.8			3944(17)			3960(19)
	$\chi_{b2}(1P)$	$0^+(2++)$	9912.21							3960(20,21)
	$\Upsilon(2S)$	$0^-(1--)$	10023.26		4425(17)			4406(17)		
	$\Upsilon(1D)$*	$0^-(2--)$	10163.7	1.4	4425(1)					
	$\chi_{b0}(2P)$	$0^+(0++)$	10232.5	0.4				4406(18)		3960(22)
	$\chi_{b1}(2P)$	$0^+(1++)$	10255.46		4425(18,19)	4640(16)				

Table 6. Continued.

	Particle		m_i	Δ	4425	4640	3943	4406	4052	3959
	$\chi_{b2}(2P)$	$0^-(2+-)$	10268.65		4425(20)					
	$\Upsilon(3S)$	$0^-(1--)$	10355.2	0.5				4406(19)		
	$X(10610)^{\pm}$*	$1^+(1^+)$	10607.2	2.0		4640(17)				
11		baryons								
	n	$1/2(1/2^+)$	939.5654		4425(2)					
	Λ	$0(1/2^+)$	1115.683							
	$\Lambda(1405)1/2^-$*	$0(1/2^-)$	1405.1	1.3	4425(8,9)	4640(14)		4406(6)		3960(6)
	$\Lambda(1520)3/2^-$*	$0(3/2^-)$	1519.5	1.0	4425(11)					
	Σ°	$1(1/2^+)$	1192.642		4425(3)	4640(3,4)				
	$\Sigma(1385)^\circ$*	$1(3/2^+)$	1383.7	1.0	4425(5)		3941(1)	4406(4)		
	Ξ°	$1/2(1/2^+)$	1314.86	0.20	4425(4)	4640(9)			4052(5)	3960(2)
	Ξ^-	$1/2(1/2^+)$	1321.71	0.07		4640(12)		4406(3)		3960(4)
	$\Xi(1530)3/2^{+\circ}$	$1/2(3/2^+)$	1531.80	0.32	4425(13)			4406(14)		
	$\Xi(2030)$**	$1/2(\geq 3/2^?)$	2025	5			3939(13)			
	Ω^-	$0(3/2^+)$	1673.45				3946(6)		4052(8)	
13	bottom	baryons								
	Λ_b°	$0(1/2^+)$	5619.51		4425(3)	4640(16)	3947(5,6)	4406(17)		3960(8)
	$\Lambda_b(5912)^\circ$	$0(1/2^-)$	5912.11			4640(5,6)	3944(9,14)	4406(12)		
	$\Lambda_b(5920)^\circ$	$0(3/2^-)$	5919.81			4640(7,8)	3940(15)		4052(15,16)	
	Σ_b^{+}*	$1(1/2^+)$	5811.3	1.9	4425(5,17)		3943(7,8)	4406(5,6,7)	4052(18)	3960(12)
	Σ_b^{*+}*	$1(3/2^+)$	5832.1	1.9	4425 (7,9,10,18)	4640(4)		4406(9,11)	4052(12,14)	3960(15)
	Ξ_b°	$1/2(1/2^+)$	5791.9	0.5				4406(4)		
	$\Xi_b'(5935)^-$	$1/2(1/2^+)$	5935.02			4640(9)	3940(10)	4406(13,14)		3960(18,19)
	$\Xi_b(5945)^\circ$*	$1/2(3/2^+)$	5948.9	1.6	4425(11,12)		3938(11,16)	4406(19)		3960(20)
	$\Xi_b^*(5955)^-$	$1/2(1/2^+)$	5955.33		4425(13)	4640(10,11)	3945(12,17)			3960(16,21)
	Ω_b^-*	$0(3/2^+)$	6046.4	1.9	4425(14)	4640(13,14.15)			4052 (17)	
14	exotic	baryons								
	$P_c(4450)^+$*		4449.8	3.0						3960(1)

4. General conclusions

Performed confirmation of CODATA relations between masses of nucleons and the electron provides a base for the Symmetry Motivated Electron–Based approach to the Standard Model development with the dominant role of two parameters of the electron: the mass value m_e and QED radiative correction [8,9]. This approach requires collection and analysis of new accurately measured data on particle masses and nuclear states.

Three parts of CODATA relations were considered:

1) The period $\delta = 16m_e$ common for many different particles, including leptons and hadrons; this period is confirmed with the analysis of data from PDG reviews. Distinguished position of the pions parameters $f_\pi, m_\pi, \Delta M_\Delta$ with n=16,17,18 provide a direct confirmation of symmetry motivated origin of the common period δ.

2) Fine structure with values of shifts 161 keV and 8×161 keV coinciding with nucleon mass splitting was earlier observed in nuclear excitations. Only recently this splitting was estimated theoretically within very large uncertainty, but its appearance in nuclear data was noticed long ago.

Now members of fine structure in nuclear data are determined within 1 keV uncertainty.

3) Similar situation exists with the parameter 170 keV=$m_e/3$ frequently seen as the analog of above mentioned fine structure. A possibility to study directly this common fine structure is a unique opportunity of the nuclear and neutron resonance spectroscopies which should not be ignored (taking into account a possibility to study position of nucleon mass within the first just discussed correlation).

4) Confirmation of CODATA relations suggested by Y. Nambu should be supplement with efforts from neutron resonance spectroscopy to check the role of the QED correction.

Table 7. Particle masses (MeV) from PDG–2017 known with an uncertainty <30 MeV given without rounding up; values with one and two meaningful numbers after the point are given directly; values with uncertainty < 8 MeV are marked by *; values with uncertainty > 8 MeV are marked by **; values which belong to members of multiplets excluded from the analysis (see text and [3,6,12]) are marked by ***.

		Particle		m_i	Δ			Particle		m_i	Δ
1	1	leptons	electron, ν	0.511			53	$D_2^*(2460)^{\pm}$*	$1/2(2^+)$	2465.4	1.3
	2	μ		105.658		5		charmed	strange	mesons	
	3	τ		1776.82			54	$D_s^{\pm}$	$0^+(0^-)$	1968.18	
2		Unflav.	mesons				55	$D_s^{*\pm}$	$0(?^?)$	2112.1	0.4
		f_π		130.7	0.4		56	$D_{so}^*(2317)^{\pm}$	$0(0^+)$	2317.7	0.6
	4	π°***	$1^-(0^-)$	134.977			57	$D_{s1}(2460)^{\pm}$	$0(1^+)$	2459.5	0.6
	5	$\pi^{\pm}$	$1^-(0^-)$	139.571			58	$D_{s1}(2536)^{\pm}$	$0(1^+)$	2535.10	
	6	η	$0^+(0^{-+})$	547.862			59	$D_{s2}^*(2573)$*	$0(2^+)$	2569.1	0.8
	7	$\rho(770)$	$1^+(1^{--})$	775.26			60	$D_{s1}^*(2700)^{\pm}$*	$0(1^-)$	2708.3	3.4
	8	$\omega(782)$	$0^-(1^{--})$	782.65		6		bottom	mesons		
	9	$\eta'(958)$	$0^+(0^{-+})$	957.78			61	$B^{\pm}$	$1/2(0^-)$	5279.32	
	10	$\phi(1020)$	$0^-(1^{--})$	1019.46			62	B°***	$1/2(0^-)$	5279.63	
	11	$b_1(1235)$*	$1^+(1^{+-})$	1229.5	3.2		63	B^*	$1/2(1^-)$	5324.65	
	12	$f_2(1270)$*	$0^+(2^{++})$	1275.5	0.8		64	$B_1(5721)^+$*	$1/2(1^+)$	5725.9	2.7
	13	$f_1(1285)$	$0^+(1^{++})$	1281.9	0.5		65	$B_1(5721)^{\circ}$***	$1/2(1^+)$	5726.0	1.3
	14	$\eta(1295)$*	$0^+(0^{-+})$	1294	4		66	$B_2^*(5747)^+$*	$1/2(2^+)$	5737.2	0.7
	15	$a_2(1320)$	$1^-(2^{++})$	1318.3	0.5		67	$B_2^*(5747)^{\circ}$***	$1/2(2^+)$	5739.5	0.7
		$\pi_(1400)$	$1^-(1^{--})$	1354	25		68	$B_J(5970)^+$	$1/1(?^?)$**	5964	5
	16	$\eta(1405)$	$0^+(0^{--})$	1408.8	1.8		69	$B_J(5970)^{\circ}$***	$1/1(?^?)$**	5971	5
	17	$f_1(1420)$	$0^+(1^{++})$	1426.4	0.9	7		bottom	strange	mesons	
	18	$\eta(1475)$*	$0^+(0^{-+})$	1476	4		70	B_s°	$0(0^-)$	5366.89	
		$a_o(1450)$**	$1^-(0^{++})$	1474	19		71	B_s^**	$0(1^-)$	5415.4	1.5
	19	$f_0(1500)$*	$0^+(0^{++})$	1504	6		72	$B_{s1}(5830)^{\circ}$	$0(1^+)$	5828.63	
	20	$f_2'(1525)$*	$0^+(2^{++})$	1525	5		73	$B_{s2}^*(5640)^{\circ}$	$0(2^+)$	5839.85	
	21	$\pi_1(1600)$*	$1^-(1^{-+})$	1662	8	8		bottom	charmed	mesons	
	22	$\eta_2(1645)$*	$0^+(2^{-+})$	1617	5		74	B_c^**	$0(0^-)$	6274.9	1.0
	23	$\omega_3(1670)$*	$0^-(3^{--})$	1667	4	9		$c\bar{c}$	mesons		
	24	$\pi_2(1670)$	$1^-(2^{-+})$	1672.2	3.0		75	$\eta_c(1S)$	$0^+(0^{-+})$	2983.4	0.5
	25	$\rho_3(1690)$	$1^+(3^{--})$	1688.8	2.1		76	$J/\psi(1S)$	$0^-(1^{--})$	3096.90	
		$\rho(1700)$	$1^+(1^{--})$	1720	20		77	$\chi_{c0}(1P)$	$0^+(0^{++})$	3414.75	
	26	$f_0(1710)$*	$0^+(0^{++})$	1723	6		78	$\chi_{c1}(1P)$	$0^+(1^{++})$	3510.66	
	27	$\phi(1800)$**	$1^-(0^{-+})$	1812	12		79	$h_c(1P)$	$?^?(1^{+-})$	3525.38	
	28	$\phi_3(1850)$*	$0^-(3^{--})$	1854	7		80	$\chi_{c2}(1P)$	$0^+(2^{++})$	3556.20	
	29	$\pi_2(1880)$**	$1^-(2^{-+})$	1895	16		81	$\eta_c(2S)$	$0^+(0^{-+})$	3639.2	1.2
	30	$f_2(1950)$**	$0^+(2^{++})$	1944	12		82	$\psi(2S)$	$0^-(1^{--})$	3686.10	
	31	$a_4(2040)$*	$1^-(4^{++}$	1995	8		83	$\psi(3770)$	$0^-(1^{--})$	3773.13	
	32	$f_2(2050)$**	$0^+(4^{++})$	2018	11		84	$\psi(3823)$	$?^?(2^{--})$	3822.2	1.2
	33	$\psi(2170)$**	$0^-(1^{--})$	2188	10		85	$X(3872)$	$0^+(1^{++})$	3871.69	
3		strange	mesons				86	$X(3900)$	$1^+(1^{+-})$	3886.6	2.4
	34	$K^{\pm}$	$1/2(0^-)$	493.677			87	$X(3915)$	$0^+(?^{++})$	3918.4	1.9
	35	K°***	$1/2(0^-)$	497.01	0.013		88	$\chi_{c2}(1P)$	$0^+(2^{++})$	3927.2	2.6
	36	$K^*(892)^{*\pm}$	$1/2(1^-)$	891.76	0.29		89	$X(4020)$	$1(?^?)$	4024.1	1.9
	37	$K^*(892)^{*\circ}$***	$1/2(1^-)$	895.85	0.20		90	$\psi(4040)$*	$0^-(1^{--})$	4039	1
	38	$K_1(1270)$*	$1/2(1^+)$	1272	7		91	$X(4140)$	$0^+(?^{1+})$	4146.8	3.1
	39	$K_1(1400)$*	$1/2(1^+)$	1403	7		92	$\psi(4160)$*	$0^-(1^{--})$	4191	5
	40	$K^*(1410$*	$1/2(1^-)$	1421	9		93	$X(4260)$*	$?^?(1^{--})$	4230	8
	41	$K_2^*(1430)^{\pm}$	$1/2(2^+)$	1425.6	1.5		94	$X(4360)$*	$?^?(1^{--})$	4341	8
	42	$K_2^*(1430)^{\circ}$***	$1/2(2^+)$	1432.4	1.3		95	$\psi(4415)$*	$0^-(1^{--})$	4421	4
		$K^*(1680$**	$1/2(1^-)$	1718	18		96	$X(4430)$**	$?^?(1^+)$	4418	15
	43	$K_2(1770$*	$1/2(2^-)$	1773	8		97	$X(4660)$*	$?^?(1^{--})$	4643	9
	44	$K_3^*(1780)$*	$1/2(3^-)$	1776	7	10		$b\bar{b}$	mesons		
	45	$K_2^*(1820$**	$1/2(2^-)$	1819	12		98	$\eta_b(1S)$	$0^+(0^{-+})$	9399.0	2.3
	46	$K_4^*(2045)$*	$1/2(4^+)$	2045	9		99	$\Upsilon(1S)$	$0^-(1^{--})$	9460.30	
4		charmed	mesons				100	$\chi_{b0}(1P)$	$0^+(0^{++})$	9859.44	
	47	D°	$1/2(0^-)$	1864.83			101	$\chi_{b1}(1P)$	$0^+(0^{++})$	9892.78	
	48	$D^{\pm}$	$1/2(0^-)$	1869.59	0.20		102	$h_b(1P)$	$?^?(1^{+-})$	9899.3	0.8
	49	$D^*(2007)^{\circ}$***	$1/2(1^-)$	2006.85			103	$\chi_{b2}(1P)$	$0^+(2^{++})$	9912.21	
	50	$D^*(2010)^{\pm}$	$1/2(1^-)$	2010.28			104	$\Upsilon(2S)$	$0^-(1^{--})$	10023.26	
	51	$D_1(2420)^{\circ}$	$1/2(1^+)$	2420.8	0.5		105	$\Upsilon(1D)$	$0^-(2^{--})$	10163.7	1.4
	52	$D_2^*(2460)^{\circ}$***	$1/2(2^+)$	2460.7	0.4		106	$\chi_{b0}(2P)$	$0^+(0^{++})$	10232.5	0.4

Table 7. Continued.

	Particle		m_i	Δ		Particle		m_i	Δ
107	$\chi_{b1}(2P)$	$0^+(1^{++})$	10255.46		143	$\Sigma_c(2520)^{++***}$	$1(3/2^+)$	2518.41	
108	$\chi_{b2}(2P)$	$0^-(2^{+-})$	10268.65		144	$\Sigma_c(2520)^{+***}$	$1(3/2^+)$	2517.5	2.3
109	$\Upsilon(3S)$	$0^-(1^{--})$	10355.2	0.5	145	$\Sigma_c(2520)^{\circ}$	$1(3/2^+)$	2518.48	
110	$\chi_{b1}(3P)$	$0^+(1^{++})$	10512.1	2.3	146	$\Sigma_c(2800)^{++***}$	$1(3/2^+)$	2801	6
111	$\Upsilon(4S)$	$0^-(1^{--})$	10579.4	1.2	147	$\Sigma_c(2800)^{+**}$	$1(3/2^+)$	2792	14
112	$X(10610)^{\pm}$	$1^+(1^+)$	10607.2	2.0	148	$\Sigma_c(2800)^{\circ *}$	$1(3/2^+)$	2806	7
113	$X(10610)^{\circ}$	$1^+(1^+)$	10609	6	149	Ξ_c^{+***}	$1/2(1/2^+)$	2467.87	
114	$\Upsilon(10860)$	$0^-(1^{--})$	10889.9	3.2	150	Ξ_c°	$1/2(1/2^+)$	2470.87	
115	$\Upsilon(11020)^*$	$0^-(1^{--})$	10993	10	151	$\Xi_c^{\prime +***}$	$1/2(1/2^+)$	2577.4	1.2
11		baryons			152	$\Xi_c^{\prime\circ}$	$1/2(1/2^+)$	2577.8	0.3
116	p^{***}	$1/2(1/2^+)$	938.2721		153	$\Xi_c(2645)^{+***}$	$1/2(3/2^+)$	2645.53	
117	n	$1/2(1/2^+)$	939.5654		154	$\Xi_c(2645)^{\circ}$	$1/2(3/2^+)$	2646.32	
118	Λ	$0(1/2^+)$	1115.683		155	$\Xi_c(2790)^{+***}$	$1/2(1/2^-)$	2792.0	0.5
119	$\Lambda(1405)1/2^{-*}$	$0(1/2^-)$	1405.1	1.3	156	$\Xi_c(2790)^{\circ}$	$1/2(1/2^-)$	2792.8	1.2
120	$\Lambda(1520)3/2^{-*}$	$0(3/2^-)$	1519.5	1.0	157	$\Xi_c(2815)^{+***}$	$1/2(3/2^-)$	2816.67	0.31
121	Σ^{+***}	$1(1/2^+)$	1189.37	0.07	158	$\Xi_c(2815)^{\circ}$	$1/2(3/2^-)$	2820.22	0.32
122	Σ°	$1(1/2^+)$	1192.642		159	$\Xi_c(2970)^{+***}$	$1/2(?^?)$	2969.4	0.8
123	Σ^{-***}	$1(1/2^+)$	1197.45	0.03	160	$\Xi_c(2970)^{\circ}$	$1/2(?^?)$	2967.8	0.8
124	$\Sigma(1385)^{+***}$	$1(3/2^+)$	1382.80	0.35	161	$\Xi_c(3055)$	$1/2(?^?)$	3055.9	0.4
125	$\Sigma(1385)^{\circ}$	$1(3/2^+)$	1383.7	1.0	162	$\Xi_c(3080)^{+***}$	$1/2(?^?)$	3077.2	0.4
126	$\Sigma(1385)^{-***}$	$1(3/2^+)$	1387.2	0.5	163	$\Xi_c(3080)^{\circ}$	$1/2(?^?)$	3079.9	1.4
127	Ξ°	$1/2(1/2^+)$	1314.86	0.20	164	Ω_c°	$0(1/2^+)$	2695.2	1.7
128	Ξ^-	$1/2(1/2^+)$	1321.71	0.07	165	$\Omega_c(2770)^{\circ}$	$0(3/2^+)$	2765.9	2.0
129	$\Xi(1530)3/2^{+\circ}$	$1/2(3/2^+)$	1531.80		13	bottom	baryons		
130	$\Xi(1530)3/2^{-***}$	$1/2(3/2^+)$	1535.0		166	Λ_b°	$0(1/2^+)$	5619.58	
131	$\Xi(1820)3/2^{-*}$	$1/2(3/2^-)$	1823	5	167	$\Lambda_b(5912)^{\circ}$	$0(1/2^-)$	5912.18	0.21
132	$\Xi(2030)^*$	$1/2(\geq 3/2^?)$	2025	5	168	$\Lambda_b(5920)^{\circ}$	$0(3/2^-)$	5919.90	0.19
133	Ω^-	$0(3/2^+)$	1673.45		169	Σ_b^{+*}	$1(1/2^+)$	5811.3	1.9
134	$\Omega(2250)^{-**}$	$0(?^?)$	2252	9	170	Σ_b^{-***}	$1(1/2^+)$	5815.5	1.8
12	charmed	baryons			171	Σ_b^{*+*}	$1(3/2^+)$	5832.1	1.9
135	Λ_c^+	$0(1/2^+$	2286.46		172	Σ_b^{*-***}	$1(3/2^+)$	5835.1	1.9
136	$\Lambda_c(2595)^+$	$0(1/2^-)$	2592.25		173	Ξ_b^{-***}	$1/2(1/2^+)$	5794.5	1.4
137	$\Lambda_c(2625)^+$	$0(3/2^-)$	2628.11		174	Ξ_b°	$1/2(1/2^+)$	5791.9	0.5
138	$\Lambda_c(2880^+)$	$0(5/2^+)$	2881.53		175	$\Xi_b'(5935)^-$	$1/2(1/2^+)$	5935.02	
139	$\Lambda_c(2940^+)^*$	$0(5/2^+)$	2939.3	1.5	176	$\Xi_b(5945)^{\circ}$	$1/2(3/2^+)$	5949.8	1.4
140	$\Sigma_c(2455)^{++***}$	$1(1/2^+)$	2453.97		177	$\Xi_b^*(5955)^-$	$1/2(1/2^+)$	5955.33	
141	$\Sigma_c(2455)^{+***}$	$1(1/2^+)$	2452.9	0.4	178	Ω_b^-	$0(3/2^+)$	6046.1	1.9
142	$\Sigma_c(2455)^{\circ}$	$1(1/2^+)$	2453.75						

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