PROCEEDINGS OF SCIENCE

Tuning effect in particle masses and nuclear data

Sergey Sukhoruchkin
B. P. Konstantinov Petersburg Nuclear Physics Institute
E-mail: Sukhoruchkin_SI@pnpi.nrcki.ru

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 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_{Ξ^-}/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_ρ/2=409 MeV, they are in ratios with the 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 the physical condensate and the estimate of the Plank Mass value $M_P = L\Delta M_\Delta(\alpha/2\pi)^{-6}$. We draw attention to the five empirical relations based entirely on the unexpectedly accurate CODATA relation with the real electron mass and the period 16m_e.

38th International Conference on High Energy Physics
3-10 August 2016
Chicago, USA

PoS(ICHEP2016)1198

Recent analysis of particle masses and new nuclear data [1-3] 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 [1-3] these values are presented (in the bottom part) as parameters of the expression n·16m$_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.

Following five empirical correlations could be mentioned [1-5].
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 1-3).
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.
3) Origin of the dark matter could be connected with the observed shifts in strange octet baryons (two bottom lines in Table 2) and above discussed interconnection between m_e and heavy fermions.
4) Evolution of nucleon mass (Fig.1) from the initial value 3M_q (top) to 6f_π+ΔM_Δ=2M''_q+ΔM_Δ (bottom) means the distinguished character of NRCQM-parameters based on QCD gluon quark-dressing effect (Fig.2 in [4]). 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" [6].
5) Confirmation with nuclear data analysis of intervals/periods Δ (observed in particle masses, boxed in Table 2, including tau-lepton mass) put forward a problem of parameters interpretation.

Table 1. 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}.

X	M	n = 1	n = 13	n = 16	n = 17	n = 18	n = 18·6	Comments
-1	3/2			m$_t$=172.0				
GeV	1	16M_q=δ°	M$_Z$=91.2	M_H=115		M_H=126		δ°=7.06
	1/2	(m_b-M_q)		M^{L3}=58				
0	1	2m_d-2m_e	m$_\mu$=106	f$_\pi$=130.7	m$_\pi$-m$_e$	ΔM_Δ=147	2M_q	
MeV	3			M''$_q$=m$_\rho$/2		M$_q$=441=ΔE$_B$		NRCQM
1	1	16m_e=δ=8$\varepsilon_\circ$	118		kδ-m$_n$-m$_e$=	170 = m$_e$/3		Part.
					=161.651			mass
keV	8				δm_N=1293			CODATA
1	1	9.5=δ'=8ε'	123	152	Δ^{TF}=161	170 (Sn)	ε_o=2m_e	
keV	3				484 (E^*)	512 (Pd)		
	4		492		648 (Pd)	682(Co)		Nuclear
	8		984	1212	1293 (E^*)	1360 (Te)		data
2	1,4	11=δ''=8ε''	143	176	749 (Br,Sb)		ε'=1188	Neutron
eV	4,8		570 (Sb)		1500 (Pd,Hf)	X=3	ε''=1.35	reson.

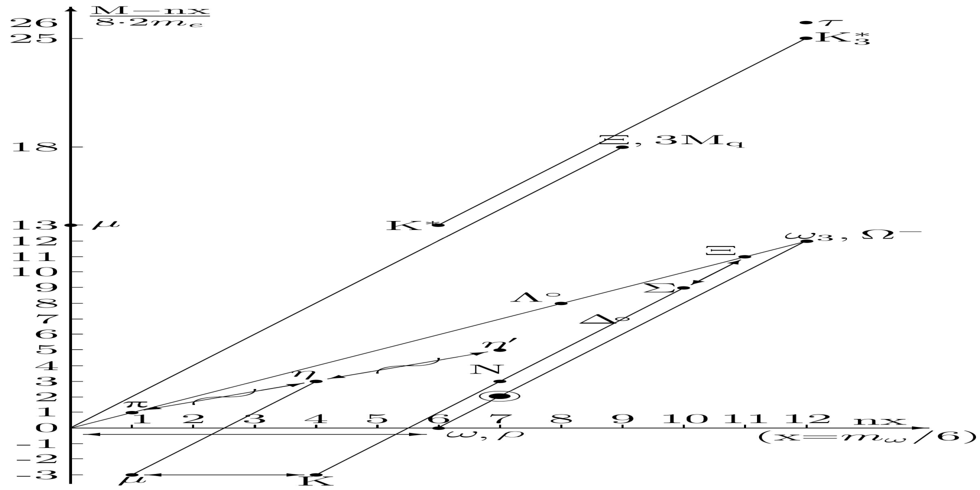

Fig. 1. Particle masses in two-dimensional representation [1-5]. Values along the horizontal axis are given in units f_π=16 · 16m_e = 130.8 MeV=16δ, remainders - on vertical axis in units 16m_e=δ. Main lines correspond to ΔM_Δ=147 MeV=18δ - parameter of quark structure derived from nucleon Δ- excitation 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 pseudoscalars $m_{\eta'}$-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 2. Comparison of particle masses with the period 16m_e=δ=8176 keV (numbers of periods k).

Particle	m_i, MeV	k	m_i-k·16m_e	Comments (in MeV)	Comments
μ	105.65837	13	-0.6294	-m_e-0.118	
τ	1776.8(2)	4 · 48· + 2·13		-5.6(2)	diff. -2m_e-(4.6 MeV=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, Fig.4 in [4]
M_q NRCQM	441	3·18			ΔE_B=441 MeV, Fig.4 in [4]
M_H/18·16	436	3·18-Δ		-5 = -Δ	
M_Z/L	440.5	3·18			diff. ≈ -2m_e
t-quark	172000(1000)	24x16x54			169540 MeV=24δ°
η'-η, η-$\pi^\pm$	409	50		≈0	
M_q^Δ NRCQM	410	50			ΔE_B=409 MeV, Fig.4 in [4]
ρ	775.49(34)	96	-9.40(34)	-9.20 = -2Δ	
M_q'' NRCQM	387.7	48	m_ρ/2	-4.60 = -Δ	
M_W/L	388.4	3·16	3f_π		diff. ≈ -2m_e
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	

To explain the period of $\delta = 16m_e$=2$\Delta - 2m_e$ (with Δ=9m_e) the symmetry motivated arguments were searched [1-5] 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 [7] (and might be connected with the gravitation [8,9]). 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 2). 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 [1-3] after comparison of the lepton ratio L with number of fermions in the central field (Table 3). 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):

= (1/3)m_e+(8/3)m_e = (1/3)M_q+(8/3)M_q
9m_e = (1/3)m_e+(8/3)m_e 9M_q = (1/3)M_q+(8/3)M_q
= (1/3)m_e+(8/3)m_e = (1/3)M_q+(8/3)M_q

Table 3. Comparison of ratios between masses m_{mu}/M_Z, $f_\pi/(2/3)m_t$ and $\Delta M_H/M_H$, 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.			hole in $1p$ shell	filled shells	

Performed here and in [1-5] analysis of particle masses and nuclear data confirmed the presence of the so-called CODATA relation with the fine structure parameters 161 keV=δm_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 [9] are confirmed now with analysis of new nuclear data [1]. The role of nuclear data in the study of tuning effect is very important.

References

[1] S.I. Sukhoruchkin, Proc. 19th Int. Conf. QCD-16, Montpellier; Nucl. Part. Phys. Proc. (in press).

[2] S.I. Sukhoruchkin, Nucl. Particle Physics Proc. **270-272** (2016) 211.

[3] S.I. Sukhoruchkin, Nucl. Part. Phys. Proc. **258-259** (2015) 268.

[4] S.I. Sukhoruchkin, Nucl. Phys. B (Proc. Suppl.) **234** (2013) 241.

[5] S.I. Sukhoruchkin, PoS (EPS-HEP2015) 527.

[6] F. Wilczek, Nature **520** (2015) 303.

[7] J. Gasser and H. Leutwyler, Phys. Rep. **87** (1982) 77.

[8] S.I. Sukhoruchkin, Prog. and Theses, 40-th Meet. Nucl. Spectroscopy, Leningrad, 1990. Nauka, p.147.

[9] S.I. Sukhoruchkin, *Symmetry Methods in Physics*, JINR E2-94-347, vol. 2, p. 528 (1994).