DISCRETENESS IN THE HADRON MASS SPECTRUM

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The presence of distinguished nuclear excitations (E^* and $D = E_i^* - E_j^*$) with multiple values of m_e=511 keV as well as presence of intervals multiple to $9m_e$ = 4.6 MeV in the binding energies of nuclei (E_B) discussed in this work [1] as the manifestation of the common properties of mass/energy spectrum of hadron system. Due to fact that such excitations and long-range correlations appear mainly in nuclei with few-nucleon configurations ones may conclude that symmetry properties of nucleon interactions reflected in the shell-model are essential to the phenomena [2, 3]. One of parameters of the long-range correlations in E_B turned to be close to $\Delta E_B(\alpha) = 8 \times 9m_e$ or near to 1/8 value of Δ-excitation of nucleon and this fact could be matched with the observation done earlier about rational (1:2:3) connection

between splitting in decuplet baryon masses (m_s), Δ-excitation of nucleon ($2\Delta M_\Delta$) and nonstrange constituent quark mass estimation $M_d = 437$ MeV (see Table 1).

The basic relation between parameters M_q and m_e in the form $m_e/M_q = \alpha/2\pi$ (where $\alpha/2\pi$ is radiation correction of electrodynamics [2]) in addition to rational relation ($n = 18 - 17 - 13$) between $\Delta M_\Delta = m_s = M_q/3$ and masses of pion (m_π) and muon (m_μ) enables one to suggest the distinguished character of that type relation in different structures interconnected by scaling factor $\alpha/2\pi$ (SFERC-model). Some of expected intervals in this model are shown in Table 2 [2].

Discreteness in the particle masses with interval $16m_e$ was found by an analysis of distribution of 19 values of independent mass splittings in the multiplets including muon and pion masses. The consideration of the existence of several parameters in representations of hadron masses was made in [2] from usual estimate of constituent quark masses from Δ-baryon and nucleon masses with the symmetric and antisymmetric configuration of quarks in nonstrange baryons. This simplified picture contains two quantitative parameters $\Delta M_\Delta = 18 \times 16m_e$ and $[q] = m_\omega/6 = (16 \times 16 - 1)m_e$ which correspond to $n = 18$ and $n = 16$ in the formula $(n \times 16 \pm 0, 1)m_e$. Intersection of this expression and the sequence of values $n' \times 9m_e$ will give besides evident cases ($n = 9 - 18$ and $n' = 16 - 32$) at ΔM_Δ the single value $n = 13$ ($n' = 23$) exactly at the muon mass with representation $m_\mu = (13 \times 16 - 1)m_e$. The value close to $9m_e$ and proximate to the electromagnetic mass difference of pion was found as observed periodic interval in nuclear binding energies (see part 1 of Table 1).

The ratio of pion mass to its charge splitting $(m_\pi\text{-}m_e)/2(\Delta m_\pi - m_e) = 17.03$ is close to integer and the value $\delta(\pi) = (m_\pi - m_e)/17 = 8,180$ MeV close to $16m_e = 8,176$ MeV may be introduced as the parameter of the discreteness and very close to it parameter from the proximity of mass differences between pseudoscalars $\delta(\eta') = (m_{\eta'} - m_\pi)/2 \times 50 = (957,75 - 139,57)/100 = 8,182(2)$ MeV and from masses of octet hyperons $\delta(\Sigma) = (1197,43 - 1115,63)/10 = 81,80(6)/10 = 8,180(1)$ MeV (again close to $16m_e$) may be introduced. Systematic trends in mass representation by $16m_e$, $9m_e$ and $17 \times 16m_e - m_e$ close to m_π was shown in [2, 3].

We see that in particle masses the numbers $n = 16$ and $n = 18$ are connected with intervals introduced semiempirically by Wick and Sternheimer $M_q = 440$ MeV$= m_\Xi/3 = 3\Delta M_\Delta = 3 \times 18 \times 16m_e$ and $M_q'' = 390$ MeV$= 3(16 \times 16 - 1)m_e$ and shown in part 4 of Table 1. The second of these intervals concides with threefold value $\Delta E_B = 18 \times 16m_e$ in the cluster-shell effects in nuclear binding energies (Part 1 of Table 1 [5]). This fact is starting point in the SYMMED — Symmetry Motivated Method of Estimation of Delta-baryon mass or delta-excitation of nucleon [2, 3]. Possible relation of m_μ and these two intervals with masses of vector boson and top-quark [4] according SFERC-model is shown in Table 2. Analysis of nuclear data may give additional information on manifestation of electrodynamics parameters and other values connected with them [1–3].

Table 1

Comparison of intervals in E_B and in particle masses with $n \times 2m_e$ [2]

^AZ	Z,N	Quantity	Value (MeV)	$n(\varepsilon_o)$	$n \times 2m_e$	Diff.
Part 1						
many		$\Delta E_B(^6He)$	46.0–41.5(1)	9×(5–4.5)	46.0–41.4	
^{139}La	57.82	$\Delta E_B(^6He)$	46.009(6)	9×5	45.990	0.019
^{133}Cs	55.78	$\Delta E_B(^6He)$	45.972(6)	9×5	45.990	−0.018
^{139}La	57.82	$\Delta E_B(2^6He)$	91.981(9)	9×10	91.980	0.001
^{39}K	19.20	$\Delta E_B(4\alpha)$	147.159(2)	18×8	147.168	0.007
Part 2						
m_π	0^-	m_π	139.5679	17×8	138.9917	0.5762
m_μ	$1/2^+$	m_μ	105.65839	13×8	106.2878	−0.62942
m_s	$3/2^+$	$m_{\Xi^-} - m_{\Sigma^-}$	147.8(6)	18×8	147.168	0.63(60)
ΔM_Δ		$(m_{\Delta^o} - m_n)/2$	146.85(30)	18×8	147.168	−0.32(30)
$M_q/3$		$(m_\eta - m_\mu)/3$	147.26(6)	18×8	–"–	0.09(6)
Part 3						
κ_T	1^-	$m_\varphi - m_\omega$	237.46(14)	29×8	237.103	0.36(14)
		$m_\omega - m_\eta$	234.5(2)	29×8	–"–	
M_T	0^-	$m_\eta - m_\pi$	407.9(2)	50×8	408.799	0.082
	0^-	$m_{\eta'} - m_\eta$	410.3(2)	50×8	–"–	
Part 4						
M_q''	1^-	$m_\omega/2$	390.97(7)	3 × 16 × 8	392.450	−1.48(7)
		$m_p - m_\eta$	390.82(19)	3 × 16 × 8	$3m_e$=1.53	−1.63
		$m_{K^o} - m_\mu$	392.01(3)	3 × 16 × 8		−0.44(3)
M_q	$1/2^+$	$m_n - m_{K^o}$	441.60(3)	3 × 18 × 8	441.50	0.1
	0^-	$m_\eta - m_\mu$	441.79(9)	3 × 18 × 8		0.29(9)
	$1/2^+$	$m_{\Xi^-}/3$	440.44(4)	3 × 18 × 8	$2m_e$=1.02	−1.06(4)
M_d		estimation	437.0	3 × 18 × 8		

Table 2

The expected from SFERC-method intervals $D = n \times 16m_e(\alpha/2\pi)^x$

x	n=1	n=13	n=16	n=17	n=18	n=3 × 18 n=3 × 16
	Part 1					
-1	$M_c + M_b$	M_Z = 91 GeV				$2m_t$ [4] 348 GeV
	Part 2					
(0)	$2(\Delta m_\pi - m_e)$	m_μ (MeV)		m_π (MeV)	ΔM_Δ (MeV)	M_q (MeV)
	8166 keV	105.658		139.568	147.1(1)	$3\Delta M_\Delta$
0	8176=$16m_e$	106.288	130.816	138.992	147.168	441.5
(0)	ΔE_B =	106.503	130.893	139.1(1)	147.159	392.4
	(^AZ)	(^{15}C)	(^{17}O)	ΔE_B	$\Delta E_B(4\alpha)$	M_q''
	Part 3					
1	9.48 keV	123.3 keV	151.7 keV	161.2 keV	170.7 keV	511.0 keV
(1)	observed	123	152	161	170	455-511
	Part 4					
2	11 eV	143 eV	176 eV	187 eV	198 eV	594 eV
(2)	observed	142		187	198	528-594

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