A Unifying Equation for almost all Constituent Quarks Masses, of Cold and Hot Genesis

Arghirescu Marius*
* *GCI-DLMFS –Romanian Academy, RO*
E-mail: *maris3a@yahoo.com,* ORCiD ID: https://orcid.org/0000-0002-3480-1207

ABSTRACT

By a Cold Genesis pre-quantum theory of particles and fields, (C.G.T.), based on Galilean relativity, which explains the constituent quarks and the resulting elementary particles as clusters of degenerate negatron-positron pairs ($\gamma^*(e^{-*}e^{+*})$) which form basic z^0 -preons of ~34 m_e which represent the CGT's prediction for the subsequent discovered boson X17 and which in CGT generates preonic bosons $z_2(4z^0)$ and $z_\pi(7z^0)$ and constituent quarks in a preonic model, an unifying equation for the constituent mass of almost all quarks is obtained from two equations, one for the preonic quarks (u-up, d-down, s-strange) in de Souza/CGT mass flavor and another for the heavy quarks (c-charm and b-bottom)- obtained for the both mass variants: CGT/Souza and Standard Model, the unifying equation resulting by the use of four parameters representing integer numbers from 0 to 3: of clustering: $(k_1 ; k_2) \le 3$ -for the number of z_2- and z_π- preonic bosons, a flavor number f = (1;2), with f = 1 for S.M.'s flavors and f = 2 for Souza/CGT flavors, compositeness number n = (1÷4): n = 1 for light/semi-light quarks; n >1 for heavy quarks) and by a multiplication factor $\alpha_q = (2n -1 -2^{n-1})$, the value n=4 giving a predicted quark, of constituent mass ~15 GeV/c^2. The Souza/CGT mass variants of the heavy quarks c (chark, ~1.7 GeV/c^2) and b (bark, 5 GeV/c^2) specific to baryons, are argued by the explaining of their forming from nucleonic quarks, by an intermediary plasmic drop- state.

Keywords: constituent quarks, quarks mass equation, preonic model, Standard Model, Cold Genesis Theory

1. INTRODUCTION

As it is known, the Standard Model of the elementary particles considers only six sub-particles named "quarks": u- (up), d- (down), s- (strange), c- (charm), b- (bottom) and t- (top), but in a variant with "color charge".

In the Standard Model (S.M.), the effective masses of quarks –necessary for explain the masses of the elementary particles (mesons and baryons) can be obtained by the constituent quark model, which considers a valence current quark (light quark: u-, d-, s-, or heavy quark: c-, b-, t-) with a specific current mass [1]: (u_c: 1.8÷2.8; d_c: 4.3÷5.5; s_c: 92÷104) MeV/c^2, respective: (c_c: 1.27; b_c: 4.18÷4.7; t_c: 173) GeV/c^2, and 'dressed' by a 'gluonic' shell formed by so-named gluons and sea-quarks [1], the electric charge of quarks being +($^2/_3$)e or –($^1/_3$)e and the resulting effective quark mass being the constituent quark mass: $m_u^\bullet$ = 336 MeV/c^2, $m_d^\bullet$ = 340 MeV/c^2, $m_s^\bullet$ = 486 MeV/c^2, respective: $m_c^\bullet$ = 1.55 GeV/c^2, m_b = 4.73 GeV/c^2, $m_t^\bullet$ = 177 GeV/c^2, and the strong interaction of quarks being explained by so-named "color charge", the gluon field between a pair of color charges forming a narrow flux tube (as a string) between them, (Lund's string model [2]).

It is also known that the constituent quark model is more of a phenomenological approach rather than a theory with specific equations for quarks masses and it doesn't provide a specific equation for quarks masses but rather assigns effective masses to quarks, based on the masses of the hadrons they form, by a specific equation, the constituent quark masses being (in the S.M.) approximate values that incorporate effects like the quark binding energy of quarks within hadrons, i.e. they were calculated from hadrons masses assuming the sum rule, using a term of hyperfine interaction, as in the strong Fermi-Breit hyperfine interaction Hamiltonian, H_{FB} [3], which is added to the sum of constituent quarks masses for obtain the particle's mass, M_p^0, having –in the mesons' case, the following form:

$$M_p^{¤}(p_m) = m_i + m_j + \mathrm{H_{FB}} ;$$

$$\mathrm{H_{FB}} = \mathrm{C} \sum_{i>j} \frac{\overline{\sigma_i}}{m_i} \cdot \frac{\overline{\sigma_j}}{m_j} (\lambda_i^c \cdot \lambda_j^c) \quad (1)$$

having explicit color and spin exchange dependence and implicit- flavor dependence, by way of quark masses, $m_{i,j}$, ($\sigma_{i,j}$ being the Pauli spin matrices, $\lambda^c_{i;j}$ being the color charge' Gell-Mann matrices and C being a constant), the constituent quark masses m_i and m_j being obtained by fitting the particle's mass formula with the known experimental value.

A similar mass formula was used for obtain the masses of minimum three preons (pre-quarks) from known quarks masses (Bevelacqua, (2019), [4]).

Mario de Souza [5], deduced the masses of baryonic ground states and the energy levels of baryon resonances with maximal discrepancy of ~5% by a simple formula, using the sum rule and the next constituent quarks masses: $m_{u,d} \approx 313$ MeV/c^2; m_s = 500 MeV/c^2; m_c = 1.7 GeV/c^2; m_b = 5 GeV/c^2, each quark resulting as composed of two *primons*, all quarks being described by four *primons* , [5], [6] .

In a Cold Genesis pre-quantum theory of particles and fields, of the author, (C.G.T., [7-10]), based on Galilean relativity, it resulted- as a more natural alternative, the possibility to explain the constituent quarks and the resulting elementary particles as formed by quasi-stable basic z^0-preons of ~34 m_e generated 'at cold', as clusters of 'gammonic' degenerate negatron-positron pairs: $\gamma^*(e^{-*}e^{+*})$ (with $e^* = (^2/_3)e$), resulting that preonic quarks can be formed 'at cold' by heavier preonic bosons, as Bose-Einstein condensate of 'gammons', in accordance to the sum rule and to the total mass/energy conservation law, ([7], p. 58). The considered "gammons": $\gamma(e^-e^+)$, (non-degenerate), were experimentally observed in the form of quanta of "un-matter" plasma, ([11], 2015).

The existence of z^0 -preon was deduced by calibrating the value: $m_k = m_e/2\alpha = 68.5m_e$ obtained by Olavi Hellman [12], by using the masses of the proton and of the Σ-baryon, [7].

The existence of a neutral boson having a mass of ~34 m_e was experimentally evidenced by a research team of the Institute for Nuclear Research in Debrecen (Hungary) in 2015, [13], which evidenced the boson named X17, by a reaction:

$$Li7 + p^+ \rightarrow Be^* \rightarrow Be8 + b^0 \rightarrow Be8 + e^+ + e^- \quad (a)$$

the mass: 17.37 MeV/c^2 being quasi-equal to that of the gamma-quantum emitted in the nuclear reaction:

$$^7\mathrm{Li} + p \rightarrow 2\alpha + \gamma(17.2\ \mathrm{MeV})\ , \qquad (b)$$

(used by Cockcroft and Walton (1932), [14]).

The light and semi-light cold quarks- which give the masses of the astro-particles, were obtained in CGT as superpositions of preonic bosons $z_2 = 4z^0$ and $z_\pi = 7z^0$ with almost the same symmetry ('star' and hexagon, (figure 1), [8; 9]), conform to a constituent quark' mass equation, (k_1; k_2-clustering numbers):

$$M_q = M_{1;2} + k_1 \cdot z_\pi + k_2 \cdot (k_1 - 2) \cdot z_2 ; \qquad (2)$$

$$M_{1;2} = M(m_1 ; m_2);\ k_1 = (0 \div 3);\ k_2(0 \div 2) < k_1$$

i.e: -(k_1 , k_2 = 0) ⇒ q = $m_{1,2}$ = 69.5 MeV; (,mark' – mesonic quark); (k_1 = 1, k_2 = 0) ⇒ q = $r^\pm$, ("rark"- un-stable quark); (k_1 = 2) ⇒ q = (p^+, n^-) = 312 MeV; 313 MeV- park; nark– nucleon' quarks;

- (k_1 = 3, k_2 = 0) ⇒ q = $\lambda^\pm$ = 435 MeV, (lark);

(k_1 = 3, k_2 = 1) ⇒q = $s^\pm$ = 504 MeV, (sark);

(k_1 = 3, k_2 = 2) ⇒ q = $v^\pm$ = 573.4 MeV , (vark);

In CGT, the gamma quantum (*γ*) of the transforming reaction: $\pi^0 \rightarrow 2\gamma$, represents a z_2(136 m_e) –boson. The masses of the astro-particles result by (2) in the approximation of the sum rule (cold forming), as consequence of the quantum fields' superposition principle applied to the particle's cold forming as sum of degenerate electrons, whose total vortical field Γ_v can explain also the nuclear force $F_n = -\nabla V_n(r)$, generated by the static pressure over the nucleon's kernel [8], [9]. The discrepancy is less than 1% , considering also the de-excitation reaction: $q^* \rightarrow q^\bullet + z^0$, for η°, Λ° and Ω^-, (Table 1). The particle N^{0*}(2972m_e) results as N^{0*}= v+ s + λ^+ = 2960.8 m_e.

Table 1: Elementary astro-particles (theoretic mass (CGT)/experimentally determined mss)

Mesons: (q- $\bar{q}$)	**Baryons**: (q-q-q); ($q^+ \equiv q(^2/_3e)$; $q^- \equiv q(-^1/_3e)$
$\mu^\pm = 2z_1 + e^\pm$ = 205 m_e ; /μ^+ (206.7 m_e);	-p_r = 2p + n = 1836.2m_e; n_e = 2n + p =1838.8m_e;
($z_1 = 3z^0$; $z_2 = 4z^0$; $z_\mu = 6z^0$; $z_\pi = 7z^0$)	/ exp. : p_r^+(1836.1 m_e) ; n_e(1838.7m_e);
$\pi^o = m_1 + \bar{m}_1$ = 270.4 m_e;/π^0(264.2 m_e)	-$\Lambda^o = s^- + n + p$ = 2212.8 m_e; / Λ^0 (2182.7 m_e)
$\pi^+ = m_1 + \bar{m}_2$ = 273 m_e; / π^+(273.2 m_e)	-$\Delta^{(++;+;0;-)} = s^\pm + \lambda^\pm + p^+(n^-)$ = 2445.6; 2453.4 m_e; /exp: $\Delta^{\pm;0}$ = 2411±4 m_e
$\pi^\pm \rightarrow \mu^\pm + \nu_\mu(2z_0)$; $\nu_\mu = z_\nu = 2z_0$	-$\Sigma^+ = v^- + 2p$ = 2346.2m_e; $\Sigma^- = v^- + 2n$ =2351.4m_e; $\Sigma^o = v^- + n + p$ = 2348.8m_e
$K^+ = m_1 + \bar{\lambda}$ = 987 m_e; / K^+ (966.3 m_e)	/exp.: Σ^+(2327 m_e); Σ^- (2342.6 m_e); Σ^0 (2333 m_e);
$K^o = m_2 + \bar{\lambda}$ = 989.6 m_e; / K^o(974.5 m_e)	-$\Xi^o = 2s^- + p$ = 2586.8 m_e; $\Xi^- = 2s^- + n$ = 2589.4 m_e;
$\eta^o = m_2 + \bar{s}$ = 1125.6 m_e; / η^0 (1073 m_e)	/exp.: Ξ^0 (2572); Ξ^- (2587.7 m_e);
$\phi^0 = \lambda + \bar{v}$ = 1975.6 m_e ; / ϕ^0 (1995 m_e)	-$\Omega^- = 3v^-$ = 3371.4 m_e; / exp.: Ω^- (3273 m_e); $N_0^{3*} \approx$ 3366 m_e

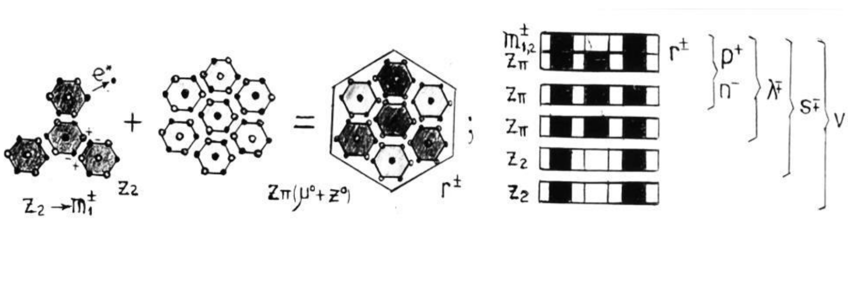

Figure 1 , *The cold forming of semi-light quarks from $m_{1;2}$ light quark and z_2- , z_π -preonic bosons*

In CGT, the equivalent of the valence current quark is the quark's kerneloid, k^q, composed of the kerneloids k^e of the quasi-electrons, e^*, of mass: $m_e^* \approx 0.81\ m_e$, which form the kerneloids of the z^0-preons, k^z.

The genesic mechanism of the preonic quarks forming is –conform to CGT, the forming and the non-destructive collapsing of 'gammonic' pre-clusters of z^0-preons (resulting as Bose-Einstein condensate) and of formed preonic pre-quarks, [9], [10].

For the constituent quarks heavier than the nucleonic quarks, it resulted in CGT as more plausible the mass values m_q^s used by M. de Souza for the baryonic quarks s (sark –in CGT), $m_s \approx 0.5$ GeV/c^2; c (chark –in CGT), $m_c \approx 1.7$ GeV/c^2; b (bark –in CGT), $m_b \approx 5$ GeV/c^2.

The top-quark, (experimental mass: 177 GeV/c^2) resulted in CGT with a mass: m ($t^\pm$) = 175 GeV/c^2 ,as being a prismatic cluster: $t^\pm$ = (7x5)m($b^\pm$) = (17($b\bar{b}$) + $b^\pm$) = $t^\pm$ = 175 GeV, [15].

The masses of the heavy quarks: chark, m(c) = 1.7 GeV/c^2 and bark, m(b) = ≈ 5 GeV, of Souza/CGT type, [5], [15], are specific to the explaining of the baryons' masses by the sum rule, (Ex.: $\Sigma_s^{*-}(1{,}385)_{ex} \approx \Sigma_s^{*-}$(v s p)$'$ = 1390 MeV), and they were explained in CGT by two de-excitation reactions of the tri-quarks cluster q* composed of three 'cold' v-quarks , i.e.:

$$c^{*\pm}\left[v^{\pm}\cdot\overline{v^{\pm}}\cdot v^{\pm}\right] \rightarrow c^{\pm} + z^0(34m_e); \qquad (c)$$

($\bar{v}$ -anti-vark).

$$b^{*\pm}\left[c^{\pm}\cdot\overline{c^{\pm}}\cdot c^{\pm}\right] \rightarrow b^{\pm} + z_3(204m_e); \qquad (d)$$

($z_3 = z_\mu$ = (2x3)z^0 = 2z_1; $\bar{c}$ -anti-chark), the value $z_3(204m_e)$ of the released mass being explained by the fact that each constituent v-quark (or its anti quark, $\bar{v}$), loose a z^0-preon, at the b-quark's forming, [15]:

$$m(b) \approx 3(3(m_v - z^0/3) - 2z^0) = 9\,(m_v - z^0); \qquad (3)$$

$(v(1123m_e \rightarrow v^\bullet(1089m_e) + z^0)$

It must be mentioned that also the Constituent Quark Model, based on Quantum Mechanics and on the Standard Model, uses two mass variants of the constituent quarks, that of baryons being higher, [16], the difference being explained by the conclusion that the mass of the strange quark, in presence of a heavy antiquark, is smaller as the effect to the different QCD interactions of the strange quark with heavy quark inside the hadrons [17], (to differences of the interaction energy' values).

Experimentally, from the total cross section of charm production in p-p and p-$\bar{\ }$p collisions at √s > 25 GeV, it resulted: $m_c = 1.48 \pm 0.03$ GeV and from the same analysis for the total cross section of charm production in π-p collisions it resulted: $m_c = 1.83 \pm 0.30$ GeV. This result is in concordance to the CGT's conclusion that the value: m(c) = 1700 MeV/c^2 corresponds to a metastable charm-quark, obtained to a lower interaction energy than that of the $c^\bullet$- quark's production, (with mass m($c^\bullet$) ≈ 1.55 MeV/c^2).

2. THE EQUATIONS OF THE HEAVY CONSTITUENT QUARKS' MASSES

2.1. The masses m_c and m_b of the baryonicquarks,

(Souza/CGT variant, flavor nr. = 2)

Because of their confinement at large scales, the quarks are invisible to the experimentalists. In this context, different theoretical analyses have been used to the extraction of the charm and of bottom quark masses. By the Karrigan's equation:

$$M_n^{¤}(q_n) \approx m_1 \cdot 3^{n-1}\ ; \quad q_n = [(q\bar{q})q]_{n-1} \qquad (4)$$

obtained by Karrigan Jr. [18] for quarks of the S.M., but with high discrepancy (~6% for masses: $M_2^\bullet = m_c^\bullet$ = 1.55 GeV/c^2 and $M_3^\bullet = m_b^\bullet$ = 4.73 GeV/c^2 , with: $m_1 = m_s^\bullet \approx 0.486$GeV/c^2), the masses of baryonic quarks c (chark) and b (bark) resulted in CGT as tri-quarks clusters, by (c) and (d), (with the released mass proportional to the quarks' binding energy), i.e. by Eq. (4) modified by (c) and (d) in the form [19]:

$$M_n(q_n^c) \approx 3^{n-1}\left[m_1 - \frac{z^0}{3}(2n-3)\right], \qquad (5)$$

(4 ≥ n>1) with $m_1 = m_v$ = 574 MeV/c^2,

(n- compositeness number; n = 2, 3, for m_c, m_b).

Eq. (5) gives: m_c = 1704.6 MeV/c^2 for n = 2 and: $m_b \approx$ 5009.6 MeV/c^2, for n = 3, (very close to the Souza's values).

An even better fit with the Souza's mass values for m_c and m_b can result by taking into account and the loosing of some internal bosons (photons –in CGT and gluons in the S.M.) corresponding to the binding energy between the q^{n-1}- current quarks during the composite q_n^c –quark' forming, by writing: (2n - 3) as: ln(e^{2n-3}) and replacing e = 2.718 with 3, i.e. in the approximated form:

$$M_n(q_n^c) \approx 3^{n-1}\left[m_v - \frac{z^0}{3}\ln(3^{2n-3})\right] \qquad (6)$$

With $m_v \approx$ 0.574 GeV, (CGT), instead of $m_s^\bullet$, Eq. (6) gives: n = 2 → m(q_2^c)c^2 = 1.703 GeV;

n = 3 → m(q_3^c)c^2 = 4.994 GeV ≈ 5 GeV; (the Souza's values) and- by n = 4→ m(q_4^c)c^2 = 14.64 GeV, (prediction of CGT).

2.2. The masses m_c and m_b of the heavy mesonic quarks,

(Standard Model's variant, flavor nr: f = 1)

The quarks of the S.M.: $s^{\bullet-}$, $c^{\bullet+}$, $b^{\bullet-}$, ($m_s^\bullet$ = 486 MeV/c^2; $m_c^\bullet$ = 1.55 GeV/c^2; $m_b^\bullet$ = 4.73 GeV/c^2) resulted in CGT [15] as de-excited quarks from the meta-stable (non-de-excited) quarks: s^-, c^+, b^-, of Souza/CGT variant, (Eq. (5)), by simple de-excitation reactions, with the loosing of a neutral boson z^0, z_6 (specific to CGT) and of a meson π^0, *i.e.*:

$$s(504) \rightarrow s^\bullet(486) + z^0;\ c(1704) \rightarrow c^\bullet(1565) + \pi^0(2z_2)$$

$b(500\quad 9) \to b^{\bullet}(4766) + z_6(2z_\pi)$ (7)

The reactions (7) correspond for c• and b•, to Eqn.:

$$M(q_n^{\bullet}) \approx 3^{n-1}\left[m_v - [\delta^{\bullet} - \frac{z^0}{k_p}(n-2)]\right]; \quad (8a)$$

($z^0 = 17.37$ MeV/c^2; $k_p \approx 2.3$; $\delta^{\bullet} = 3z^0 = 52.1$MeV);

$(m_v - \delta^{\bullet}) = (2m_s + m_v - z^0)/3] = 521.5$ MeV/c^2, (8b)

(Eq. (8b) resulted by taking into account the reaction (c) of the c-quark's obtaining and the figure 1).

By n = 2 and n = 3, Eq. (8) gives:

$m_c^{\bullet}$ (c•) = 1564.5 MeV/c^2; $m_b^{\bullet}$ (b•) = 4762 MeV/c^2, (discrepancy under 1%).

By taking into account also the loosing of some internal bosons from the bosonic shell (photons –in CGT) corresponding to the binding energy between the current q^{n-1}-quarks at the composite q_n^c –quark' forming, i.e. by taking: $\delta > \delta^{\bullet}$, the experimental values: $m_c^{\bullet}$ $(1550)_{ex}$ and $m_b^{\bullet}(4730)_{ex}$ can be obtained almost exactly from a modified form of Eq. (8), similar to Eq. (6), by writing in Eq. (8): $\ln e^{n-2}$ instead of (n-2) and replacing e = 2.718 and k_p with 3, resulting- for $M_n^c(q_n^{\bullet})$, the form [15]:

$$M_n^c(q_n^{\bullet}) \approx 3^{n-1}\left[m_v - (\delta - \frac{z^0}{3}\ln 3^{n-2})\right]; \quad (9)$$

($\delta = 55$ MeV/c$^2 > \delta^{\bullet}$)

($m_v = m(v^{\pm}) \approx 574$ MeV/c^2), the value $\delta = 55$ MeV/c^2 being obtained with: $M_n^c(n=3) = m_b^{\bullet} = 4730$ MeV/c^2, (the known experimental value $m_b^{\bullet}$).

For n = 2, Eq. (9) gives: $M(q_2^{\bullet})c^2 = 1557$ MeV ≈ m(c•), - almost equal to the known experimental mass ($m_c^{\bullet}$ $(1550)_{ex}$ = 1.55 GeV/c^2), so Eq. (9) is valid.

From Eqs. (6) and (9), it was obtained a single equation for the quarks: c, b, c•, b•, in the form [20]:

$$M(q_n^f) = 3^{n-1}\{m_v - (2-f)\delta - (z^0/3)\ln[3^{(2n-3)}/3^{(2-f)(3n-5)}]\}; \quad (\delta = 55 \text{ MeV/c}^2 > \delta^{\bullet}) \quad (10)$$

($m_v = m(v^{\pm}) \approx 574$ MeV/c^2; $\delta = 55$ MeV/c^2), $f = f_q =$ (1; 2) being a 'flavor' number of the heavy quarks.

Eq. (10), by $f = |f_q| = 1$ retrieves Eq. (9) for $M(q_n^{\bullet})$ and by $f = |f_q| = 2$ it retrieves Eq. (6) for $M(q_n^s)$.

3. THE OBTAINING OF A SINGLE EQUATION FOR THE MASSES OF QUARKS

3.1. A quasi-unitary equation for constituent quarks masses

A such equation results by writing in Eq. (10) the Eq. (2) instead of m_v and: ($z^0 + \beta$) instead of δ, ($\beta = \delta - z^0 = 37.63$ MeV/c^2), and by multiplying the last part of Eq. (10) with $|\alpha_q| = |(2n - 1 - 2^{n-1})|$, a factor which gives: $\alpha_q = 0$ for n = 1, $\alpha_q = 1$ for n = 2 or 3 and $|\alpha_q| = 1$ for n = 4. It results the equation:

$$M_q(q_n^f) = 3^{n-1}\left\{[M_{1,2} + k_1 \cdot z_\pi + k_2 \cdot (k_1 - 2)\cdot z_2 - z^0(2-f)] - [\beta(2-f) + \frac{z^0}{3}\ln\frac{3^{(2n-3)}}{3^{(2-f)(3n-5)}}]\cdot\left|2n - 1 - 2^{(n-1)}\right|\right\}; \quad (11)$$

$$M_{1,2} \approx (1/\alpha)\, m_e;\ k_1 = 0 \div 3;\ k_2 = 0 \div 2 < k_1;\ f = (1;2);\ n = 1 \text{ if } (k_1 + k_2) < 5;\ n = 1 \div 4 \text{ if } (k_1 + k_2) = 5$$

with: $M_{1;2} = M(m^{\pm}) = \left(1/\alpha - 0.5 \pm 1.3\right)m_e \approx 69.5$ MeV/c^2, ($\alpha = 1/137$ –the fine structure' const.).

The flavour number is: f = 1- for S.M.'s variant, (being applicable only for $k_1 > 2$); f = 2- for the Souza/CGT mass variant.

For n = 1 it is retrieved Eq. (2) (for light and semi-light quarks), and for ($k_1 + k_2$) = 5; n >1, it is retrieved Eq. (10) for m(c); m(b); m(c•) ; m(b•) . Also, taking $e^{(2n-3)}/e^{(2-f)(3n-5)}$ instead of $3^{(2n-3)}/3^{(2-f)(3n-5)}$ there are obtained –with f = 1; 2, the Eqs. (6) and (9) -with $k_p = 3$, corresponding approximately to the de-excitation reactions (c) and (d) and to the sum rule.

The link with the binding energy between the current quarks (the kerneloids of the constituent quarks –in CGT) is similar to the binding energy per nucleon loosed at the nucleus' forming.

- The mass of the lost internal bosons (photons- in CGT) per v-quark: $\Delta_q^{\bullet} = [\delta - \delta^{\bullet}] \approx 2.55$ MeV/c^2, is a little increased for n = 3, by $\{[\delta-\delta^{\bullet}]-[(z^0/3)\ln 3^{(n-2)} - (z^0/2.3)(n-2)]\} > 0$, (with ~1.2 MeV/c^2 per v-quark).

3.2. The Gell Mann-Oakes-Renner relation

The GMOR relation, i.e. the relation [21]:

$$M_m^2 \approx B(m_{q1} + m_{q2}), \quad (12)$$

between the masses M_m of (π, K, η)-mesons and the masses m_q of their light current quarks, is explained in CGT by the increasing of the mean value of current quarks' density and of the sum of their volumes (given as sum of kerneloids of z^0-preons) proportional to the mass of the pseudo-scalar (π, K, η)-mesons at a given internal temperature T_i , i.e.:

$$(\upsilon_{q1} + \upsilon_{q2}) \approx \upsilon_{z0}(M_p/m_{z0}) = k_1 M_p; \quad (13a)$$

$$\bar{\rho}_q = \tfrac{1}{2}(\rho_{q1} + \rho_{q2}) \approx k'(M_p/\upsilon_p) = k_2 M_p; \quad (13b)$$

$$\Rightarrow \textstyle\sum_q m_q = (m_{q1} + m_{q2})$$

$$\Rightarrow (\upsilon_{q1} + \upsilon_{q2})\bar{\rho}_q \approx k_1 k_2 M_p^2 = B^{-1} M_p^2 \quad (13c)$$

by the fact that –conform to CGT [8], for particles with mass lower or equal to the nucleon's mass, it may be considered a quasi-equal volume υ_p(a = 1.41 fm) as that of the classic electron having the e-charge contained by its surface, (r_e = 1.41 fm). The relation:

$$3 \cdot [M^2(\eta^0)_e + M^2(\pi^0)_e] \approx 4M^2(K^0)_e \quad (14a)$$

(valid by discrepancy: ~ 3.2 %), verify the GMOR relation by the CGT's ratios: $m_{S\bullet}/m_m^-$; m_λ/m_m^-:

$3[(m_{S\bullet}/m_m^-) + 1 + 2] \approx \quad 4(m_\lambda/m_m^- + 1) = 102$,

(discrepancy: 2.6%) by the values: (m_{m-} = 3; m_λ =74) MeV/c^2, $m_{s\bullet}$ = 91 MeV/c^2 –obtained in CGT [19], so is verified the GMOR relation by the fact that:

$$3 \cdot [M^2(\eta^0)_e + M^2(\pi^0)_e]/4M^2(K^0)_e = \\ = 3[(m_{S\bullet} + m_m^-) + 2m_m^-]/4(m_\lambda + m_m^-). \quad (14b)$$

The relation used by Weinberg:

$$\frac{M_\pi^2}{2m_{u,d}} \approx \frac{M_K^2}{m_{S\bullet} + m_u} \approx \frac{M_\eta^2}{m_{S\bullet} + m_d}, \quad (Weinberg),$$

in CGT must be written in the form:

$$\frac{M_\pi^2}{2m_{m-}} \approx \frac{M_K^2}{m_\lambda + m_{m-}} \approx \frac{M_\eta^2}{m_{S\bullet} + m_{m-}}; \Rightarrow \frac{135^2}{2x3} \approx \frac{498^2}{74+3} \approx \frac{548.3^2}{91+3} \quad (15)$$

which gives the ratios: 3182; 3303; 3306.5, (so –an acceptable discrepancy).

4. THE CGT's EXPLAINING FOR NUCLEON's TRANSFORMING INTO HEAVY QUARKS

4.1. The CGT's explanation of the nucleons' transforming into (semi)light quarks ($\lambda^\pm$; $s^\pm$; $v^\pm$; $s^\bullet$; $v^\bullet$):

It is known that the hot, dense medium produced in the collisions is composed of partons, i.e.- of current quarks and gluons forming a quark–gluon plasma (QGP), described by the laws of quantum chromodynamics (QCD).

- According to QCD, high-momentum partons produced in the initial stage of a nucleus–nucleus collision will undergo multiple interactions inside the collision region prior to hadronization.

For sufficiently high energies, perturbative QCD consistently predicts that the small-x gluons in a hadron wave-function should form a Color Glass Condensate (CGC) -a state characterized by a hard saturation momentum $Q_s(x) \approx 1$ GeV, which grows rapidly with 1/x, (x- distance between gluons), high density effects being produced at $Q^2 < 50$GeV^2 , [22, 23], a type of matter theorized to exist in atomic nuclei when they collide at near the speed of light, such collision determining very small momenta of gluons and a very small x_B - Bjorken scaling variable [24], i.e. in the CGC- phase, the gluons have a very high density.

This dynamics of small-x degrees of freedom in hadrons is described with the Color Glass Condensate (CGC) effective theory [25], and from Q^2 = 45 to 150 GeV^2, there are included the heavy charm and bottom quarks, [26].

-In CGT , the Color glass condensate has as proximal correspondent the quasi-crystalline cluster of preonic (and electronic) kerneloids and its forming at high impact energies has as a relative corresponding scenario in CGT the light quarks forming from preonic bosons (z^0, z_2 , z_π) by clustering and the composite quarks forming from lighter quarks (thereafter – strongly bound in the formed kerneloidic cluster of preonic kerneloids, but still in a distinct specific form).

Conform to the CGT's scenario, the forming of heavier quarks from nucleonic quarks (u/d –quarks, in S.M. and p/n- quarks –in CGT) at high impact energy between nucleons and/or nuclei, is generated by the forming of an intermediary state, corresponding to the forming of a glowing plasmic ‚drop', (P.D.), formed by mesonic current quarks and kerneloids of preonic bosons (z^0, z_2 , z_π) generated by the ‚melting' of the valence current quarks of the collided nucleons, (of the nucleonic quarks' kerneloids), corresponding to an expanded ‚glasma', but with kerneloids of mesonic quarks ($m_{1,2}$- specific to CGT) instead of nucleonic current quarks and with kerneloids of preonic bosons instead of gluons.

From this ‚plasmic drop' PD , conform also to the quarks formalism of the Standard Model, heavier quarks are formed by re-clustering and re-arranging of stable preonic bosons (z^0, z_2 , z_π) conform to the CGT's model of quark, (figure 1).

We observe in this scenario that a re-clustering form of the v-quark (from nucleonic quarks to v-quark) is the transition v-quark variant:

$$v^- = (m_2 + 4xz_\pi + z^0) = (4+4x7+1)z^0,$$

instead of ($m_2 + 3xz_\pi + 2z_2$), and this intermediary variant can explain more easily the transforming: $v \rightarrow v^\bullet + z^0$ and the higher stability of $v^\bullet$ -quark –in this case, i.e.:

$$v^{\bullet-} = (m_2 + 4xz_\pi) = (4+4x7)z^0 .$$

This more stable form $v^{\bullet-}$ explains also the reaction (d) and the Eq. (3) of the bark's forming.

Also, in the $s^\bullet$-quark's case, its higher stability than the stability of its ‚cold' variant:

$$s^- = (m_2 + 3xz_\pi + z_2) = (4+3x7+4)z^0$$

can be explained by the hypothesis that the $s^\bullet$-quark's charge is (formally) given by the loosing of a quasi-electron $e^{*-} = (^2/_3)e^-$ by a bosonic preon z_π^0 and the acquiring of a negatron e^- by the charged bosonic preon $z_\pi^+(^2/_3e^+)$, the $s^\bullet$-quark resulting –by re-clusterizing, in the form:

$$s^{\bullet-} = (z_\pi^- + 3xz_\pi) = (4x7)z^0 = 486 \text{ MeV/c}^2 –$$

a form more stable than the ‚cold' form:

$$s^- = (m_2 + 3xz_\pi + z_2).$$

So, the $s^{\bullet-}$ -quark formed by re-clusterizing from a PD-state results as more stable than the λ -quark – specific to CGT. Also, it results as possible and the quarcic less stable form:

$$y^{\bullet-} = (z_\pi^- + 3xz_\pi) = (5x7)z^0 = 608 \text{ MeV/c}^2.$$

So, conform to CGT, in concordance with Eq. (2) and figure 1, the quasi-stable (semi)light quarks $v^{\bullet+}$ and $\bar{v}^{\bullet-}$ can be produced from nucleonic quarks p, n, in nucleons' collisions, from a PD-state, by the next reaction based on the total mass' conservation law:

a) $(p+p) \rightarrow v^{\bullet+} + m_1 = \bar{v}^{\bullet-} + z_2 + e^+$; (16)
b) $(p + n) \rightarrow \bar{v}^{\bullet-} + z_2$; c) $(p + n) \rightarrow v^{\bullet-} + m_1$;
d) $(n + n) \rightarrow v^{\bullet-} + m_2$; e) $(2p + n) \rightarrow v^{\bullet-} + 2m_1 + 2z_\pi$;
e') $(2n + p) \rightarrow v^{\bullet+} + 2m_2 + 2z_\pi$

Also, it results that the quarks : $\lambda^\pm$, $s^\pm$ and $s^\bullet$ can result by the decaying of a quark $v^\bullet$ or v^-, conform to:
f) $v^{\bullet-} \rightarrow \lambda^- + z_\pi$; g) $v^- \rightarrow s^- + z_2$; (17)
h) $v^{\bullet-} \rightarrow s^{\bullet-} + z_2$; $[s^{\bullet-} = (z_\pi^- + 3x z_\pi)]$
The reaction h) corresponds to the (virtual) transferring of the $m^\pm$-quark's charge to a z_π -preonic boson.

4.2. The CGT's explanation of the nucleons' transforming into heavy quarks (c, $c^\bullet$, b, $b^\bullet$)

a) *The chark's forming:*
-Looking the forming of the heavy quarks c- and b- by re-clusterizing from a PD-state, the quescion is: „why the c-quark of Souza/CGT variant is formed by the combination: $c^\pm = (v + \bar{v} + v^\bullet)$ and not: $(v + \bar{v} + v^-)$ or $(v^\bullet + \bar{v}^\bullet + v^\bullet)$?"

Glashow predicted that the down quark of a proton could absorb a W+ and become a charm quark and then, the proton would be transformed into a charmed baryon before it decayed into several particles, including a lambda baryon. The charm-quark's mass is approximately half of the rest mass of J/ψ (J/psi) meson, (3.0969 GeV/c^2), consisting of a charm quark and a charm antiquark. It is widely expected that some J/ψ are produced and/or destroyed at time of QGP hadronization.

-Conform to CGT's model, the c -quark (of Souza/CGT flavor) is formed by re-clusterizing from a common PD-state, resulting at two nucleons collision, conform to the mass conservation law, in accordance to the reactions (16):
Chark: $c^\pm = (v + \bar{v} + v^\bullet) = (v^{\bullet-} + 2z^0 + \bar{v}^{\bullet-}) + v^{\bullet-} = [p + n - (z_2 - 2z^0) + n + n - m_2] + (p + n - m_1) =$
$= 4n + 2p - (m_1 + m_2 + z_2 - 2z^0) = 2n_e - (m_1 + m_2 + z_2 - 2z^0) = 1\,n_e + n + m_1 + m_2 + 4z_\pi - m_1 - m_2 - 2z^0$;

$\Rightarrow c^\pm = 1n_e + n + 4z_\pi - 2z^0 = 1n_e + n + 2z_\pi + 3z_2$. (18)

It results that- conform to CGT's model, a c-quark is formed only by preonic bosons z_π and z_2 , (the mesonic $m^\pm$ -quark resulting from a z_2 –boson, that is charged by the loosing of a quasielectron e^{*-}).

The reaction that generates the c-quark can be obtained by reactions (16), considering that it is generated by the collision of two neutrons n_e with the forming of also neutral pseudo-quarks (p^0, n^0) and a neutral form of μ-meson, in the next way:
$c^- = 1n_e + n + 2z_\pi + 3z_2$; (19a)
$(2z_\pi + 3z_2 = n^0 + \pi^0 = n + m_1 + \bar{m}_1)$;
$(p \rightarrow \pi^0 + \mu^0 + m_1$; $n \rightarrow \pi^0 + \mu^0 + m_2)$
$c^+ = (1\,n_e + p) + [n + p - (\mu^+ + m_2)]$; $n + p \rightarrow n + m_1 + 2z_\pi = n + m_1 + \pi^0 + \mu^0 = n^0 + \bar{m}_2 + \pi^0 + \mu^0$;
$\Rightarrow n_e \rightarrow n + n^0 + \bar{m}_2 + \pi^0 + \mu^0$;
$p_r \rightarrow p + n^0 + \bar{m}_2 + \pi^0 + \mu^0$; $\Rightarrow$
a) $2n_e \rightarrow c^- + \bar{m}_2 + \mu^0 = \tau^0 + \mu^0$; (19b)
a') $2n_e \rightarrow c^+ + \bar{m}_2 + \mu^- = \tau^+ + \mu^-$,
($\tau = \tau(1{,}773)$), or:
b) $2n_e \rightarrow \bar{c}^+ + \mu^+ + m_2 = \tau^- + \mu^+$; (19c)
b') $2n_e \rightarrow \bar{c}^- + m_2 + \mu^0 = \tau^0 + \mu^0$,
τ representing in CGT an exotic meson (and not lepton- as in the S.M.). It results also that:
$n_e + p_r \rightarrow c^+ + \bar{m}_2 + \mu^0 = \tau^+ + \mu^0$;
$n_e + p_r \rightarrow \bar{c}^+ + m_2 + \mu^0 = \tau^- + \mu^0$; (20)
$n_e + p_r \rightarrow c^- + \mu^+ + \bar{m}_2 = \bar{c}^- + \mu^+ + m_2 = \tau^0 + \mu^+$
Other similar reactions are:
$c^- = (1\,n_e + n) + [n + p - (\mu^+ + m_2)] \Rightarrow$
$2n_e \rightarrow c^- + \mu^+ + \bar{m}_1 = \tau^- + \mu^+$;
$2n_e \rightarrow \bar{c}^- + \mu^- + m_1 = \tau^+ + \mu^-$ (21)
$n_e + p_r \rightarrow c^+ + \bar{m}_1 + \mu^+ = \tau^0 + \mu^+$;
$n_e + p_r \rightarrow \bar{c}^+ + \mu^+ + m_1 = \tau^0 + \mu^+$ (22)

$2n_e \rightarrow c^{+\bullet} + \mu^+ + m_2 + \pi^0 = c^{-\bullet} + \mu^+ + \bar{m}_2 + \pi^0$
$\Rightarrow 2n_e = \tau^{\bullet 0} + \pi^0$; $(\tau^{\bullet 0} = \tau^{\bullet 0}(1755))$ (23)
$2p_r = c^+ + \mu^+ + \bar{m}_2 = \tau^+ + \mu^+$; $2p_r = \bar{c}^- + \mu^+ + m_1$,
$\Rightarrow 2p_r = \tau^+ + \mu^+ = c^{+\bullet} + \mu^+ + \bar{m}_2 + \pi^0$ (24)

Indeed, the tau-particle was detected in a series of experiments between 1974 and 1977 by Martin Lewis Perl and Yung-su Tsai's colleagues at the Stanford Linear Accelerator Center (SLAC) and Lawrence Berkeley National Laboratory (LBL) group, [27], but indirectly, by a reaction:
$e^+ + e^- \rightarrow e^\pm + \mu^\mp +$ two undetected particles (25)
It was proposed that this event was the production and subsequent decay of a new particle pair:
$e^+ + e^- \rightarrow \tau^+ + \tau^- \rightarrow e^\pm + \mu^\mp + 4\nu$ (26)
We obtained- by CGT, the conclusion that a $(\tau^+ + \tau^-)$-pair can be produced by four collided nucleons, but according to (26), (27), it results that a $(e^+ + e^-)$ –pair of collided electrons can produce locally, inside an atomic nucleus, a plasmic drop (PD) that can generate- by re-clusterizing, a $(\tau^+ + \tau^-)$-pair.

A supplementary argument for this conclusion is also the fact that the energy to produce a $(\tau^+ + \tau^-)$-pair is similar to the threshold for D meson production, this particle having a $c^\bullet$-quark in its structure:
$D^+ = (c^\bullet\ \bar{d})$; $D^0 = (c^\bullet\ \bar{u})$; $D^- = (d\ \bar{c}^\bullet)$, and a mass: $m(D^\pm) = 1869.62$ MeV/c^2, explained in CGT by the structure: $D^+ = (c^{\bullet+}\ \bar{n})$; $D^0 = (c^{\bullet+}\ \bar{p})$; $D^- = (n\ \bar{c}^\bullet)$ and the masses: $m(c^\bullet) = 1557$ MeV/c^2; $m(u/d) \approx 313$ MeV/c^2, which give: $D^- = (n\ \bar{c}^\bullet) = 1870$ MeV/c^2.

The D –meson was discovered on 3 May 1976 at SLAC, when was identified a 1.87 GeV/c^2 peak, which suggested the presence of a neutral charmed D meson- according to Glashow's prediction.

The fact that the D meson preferentially decays into kaons (K) and pions (π) can also be explained in CGT by the $c^{\bullet}$ - and u/d- quarks' (or anti-quarks') transforming into $s^{\bullet}$- and m- quarks (or anti-quarks) and neutral preonic bosons of CGT.

- If the collision is produced between nucleons or light nuclei and both reactions 23) and 24) occur, it results the probability of a J/ψ -meson forming, i.e.:

$$2n_e + 2p_r \rightarrow (\bar{c}^{+\bullet} + m_2 + \mu^+ + \pi^0) + (c^{+\bullet} + \mu^+ + \bar{m}_2 + \pi^0) \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + \pi^0(m_2\ \bar{m}_2) + 2(\mu^+ + \pi^0); \quad (27a)$$

$$\Rightarrow 2n_e + 2p_r \rightarrow J/\psi^*(c\ \bar{c}) + \pi^0 + 2\mu^+ \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 3\pi^0 + 2\mu^+ \ ; \quad (c \rightarrow c^{\bullet} + \pi^0) \quad (27b)$$

$$4n_e \rightarrow J/\psi^*(c\ \bar{c}) + \pi^0 + (\mu^+ + \mu^-) \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 3\pi^0 + (\mu^+ + \mu^-) \ ; \quad (J/\psi^*(c\ \bar{c}) = J/\psi^*(3400)) \quad (27c)$$

Indeed, it is known that the J/ψ-meson is produced in p-p collisions at high energy. Eq. (27) also explains the experimentally observed reaction: $J/\Psi \rightarrow \mu^+ + \mu^-$.

The observed reaction: $D^* + \bar{D}^* \rightarrow J/\Psi$ + meson, is explainable in CGT by the conclusion that the mesons $D_s^{\pm}(1968.5)$ and $D^{*\pm}(2010)$ differ from $D^{\pm}$ (1869.6) and $D^0(1864.5)$ by a μ -meson (105.7 MeV/c^2) , (resulting: $D_s^{\pm}(1970.2) = D^0 + \mu^{\pm}$), and respectively by a π^0 –meson, giving:

$$D^{*\pm}(2010) = D^{\pm}(2008.6) \text{, i.e. –with the structure:}$$

$$D^{*\pm}(2010) = (c\ \bar{d}), \quad (\text{by } c(1703))$$

In this case, we have:

$$D^* + \bar{D}^* \rightarrow (c\ \bar{d}) + (d\ \bar{c}) \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 2\pi^0 + (d\ \bar{d}) \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 3\pi^0 + s^{\bullet 0}(4z_{\pi}) \ ; \quad (\text{by } s^{\bullet 0}(486)).$$

In this case, the experimentally observed reaction: $J/\Psi + \pi \rightarrow D + \bar{D}^*$ is explained in CGT by the form:

$$J/\Psi + \pi^0 + (d\ \bar{d}) \rightarrow D + \bar{D}^*$$

(recombining after the PD-state generating).

The fact that enhanced production of J/ψ is expected in heavy ion experiments at LHC , after quark-gluon plasma forming [28], is in concordance to the previous reactions resulting by CGT, (the J/ψ meson being produced also by e + p and e +Au collisions at high energies, (hundred of GeV).

In 2020, at the detector of the Large hadrons collider (LHCb) it was observed a narrow $X(6900)$ structure in the di-J/ψ channel [29], interpreted as a tetraquark with four charm quarks, $T_{cc^-c^-c}$, [30].

A search made for $(cc\ ^-c\ ^-c)$- tetraquarks decaying, in which two decay channels, $J/\psi + J/\psi \rightarrow 4\mu$ and: $J/\psi + \psi(2S) \rightarrow 4\mu$, were studied, evidenced that significant excess were seen in the di-J/ψ channel consistent with a narrow resonance at 6.9 GeV and a broader structure at lower mass, [31].

We can see that Eq. (30), doubled, can explain the resonance of 6.9 GeV as corresponding to the rest energy of two J/ψ –meson (~6200 MeV) , two π^0-mesons (~278 MeV) and four μ -mesons, (4x105.77 = 423 MeV), in concordance to the conclusion that the c-quark (chark –of Souza/CGT type) represents a meta-stable state, which is transformed quikly into the S.M's flavour, $c^{\bullet} = (c - \pi^0)$.

So, the explanation of the tetraquark X(6900) is – conform to Eq.(27), the fact that –from the PD-state-generated by four pairs ($n_e + p_r$), the formed c- , $\bar{c}$-quarks (of Souza/CGT type) are transformed into $c^{\bullet}$-, $\bar{c}^{\bullet}$-quarks (of S.M.'s) with the loosing of two π^0 –mesons/(c- , $\bar{c}$)-pair, the remained mass forming the X-tetraquark, which is transformed by a reaction:

$$X(6900) \rightarrow 2J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 2\pi^0 + 2(\mu^+ + \mu^-) \quad (28)$$

Another reaction, resulting from Eqs. (19) , (24), is:

$$(\tau^- + \tau^+) \rightarrow \bar{c}^+ + m_2 + c^+ + \bar{m}_2 \rightarrow J/\psi(c^{\bullet}\ \bar{c}^{\bullet}) + 3\pi^0 \quad (29)$$

$$(c \rightarrow c^{\bullet} + \pi^0).$$

So, it results that the forming of c-quark (in Souza/CGT mass variant) can be explained by the fact that- at nucleons' collision, from the generated PD-state is clusterized first the most stable particle: the muonic boson μ, which is emitted, while the remained part represent a light m- quark and a c-quark thereafter formed by re-clusterizing of the remained plasmic drop, (PD), c^- -quark resulting from $2n_e$ and c^+ - quark resulting from ($n_e + p_r$); (n_e – neutron; p_r –proton).

In conclusion, the mass and the quarcic structure of the c-quark (of Souza/CGT flavor) is justified by the fact that- in the process of the PD-state of two collided nucleons , the μ^0-neutral muons forming (which can transform into charged muon by electron acquiring) explains in the sametime also the c-quark's forming from the PD-state of the two nucleons, by the reactions: $p \rightarrow \pi^0 + \mu^0 + m_1$; $n \rightarrow \pi^0 + \mu^0 + m_2$.

If π^0 from the transformation of p- or n- quark is transformed conform to: $\pi^0 \rightarrow m_1 + \bar{m}_1$, or: $\pi^0 + \gamma^{\bullet}(e^-e^+) \rightarrow m_2 + \bar{m}_2$, the emission of $\pi^{\pm}$ -mesons from nucleons is also explained, by :

$$n \rightarrow (\pi^- + \mu^0 + m_1); \quad p \rightarrow (\pi^+ + \mu^0 + m_2) \quad (30)$$

$$(m_2 \rightarrow m_1 + e^- + \bar{\nu}_e)$$

i.e. by e -charge transferring , (also physically possible – in CGT but also in the quarks' formalism), the reactions of $\mu^{\pm}$ -mesons emission by nucleons being also explained.

It results also that –in CGT, every charged quark and the μ- lepton can have a neutral correspondent (pseudo-quark) with almost the same mass.

-So, in concordance to Eqs. (25), (26) and (27), the CGT's model predicts and the reactions:

$$e^+ + e^- + (4n_e) \rightarrow J/\psi(c\ \bar{c}) + \pi^0(m_2\ \bar{m}_2) + (\mu^+ + \mu^+); \quad (J/\psi^*(c\ \bar{c}) \approx 3400 \text{ MeV/c}^2) \quad (31a)$$

$$e^+ + e^- + (4n_e) \rightarrow (D^- + D^+) \rightarrow J/\psi^*(c\ \bar{c}) + \pi^0(2z_2) + s^{\bullet 0}(4z_{\pi}) \quad (31b)$$

The resonance of the J/psi particle, detected at 3.7 GeV/c^2, (named: 'psi prime'), argues the existence of the particle: $J/\psi^*(c\ \bar{c})$ = 3406 MeV/c^2 also by the fact that this resonance $\psi'(3700)$ can be explained in CGT as being a baryon :

$\psi'(2c^+ + n^-)$ = 3719 MeV/c^2 .

The Xi double-charm baryon: $\Xi_c{}^+{}_c{}^+$, with mass: $m(\Xi_{cc})$ = 3621.4 MeV/c^2, is explained in CGT by the structure: $\Xi_c{}^+{}_c(c^\bullet,\ c^\bullet,\ s) = \Xi_c{}^+{}_c(3618)$, (with mass : $m(\Xi_{cc})$ = 3618 MeV/c^2, (a very low discrepancy).

The charmed Λ-baryon, $\Lambda_c{}^+(2286.5)$ can be explained in CGT by the sum rule applied for bound constituent quarks, as:

$\Lambda_c{}^+(c^{\bullet+},\lambda^{\bullet-},p^+) = (1557+417.6+312) = 2286.6$MeV/$c^2$.

The known reaction: $\Xi_c{}^+{}_c \rightarrow \Lambda_c{}^+ + K^- + 2\pi^+$, is explained in CGT by the next reaction:

$\Xi_c{}^{2+}{}_c(c^\bullet, c^\bullet, s^+) \rightarrow \Lambda_c{}^+(c^{\bullet+}, \lambda^{\bullet-}, p^+) + K^-(\lambda^- + \bar{m}_1) + 2(m_1 + \bar{m}_2{}^-)$; $s^+ \rightarrow p^+ + z_\pi + z_2$; $c^{\bullet+} \rightarrow (v^{\bullet-} + \bar{s}^-) + s^+$;

$(v^{\bullet-} + \bar{s}^-) \rightarrow (\lambda^{\bullet-} + \bar{\lambda}^-) + 3z_2 \rightarrow (\lambda^{\bullet-} + \bar{\lambda}^-) + (m_2{}^- + \bar{m}_2{}^-) + z_2$; $(c^{\bullet+} + \lambda^{\bullet-} + p) \rightarrow \Lambda_c{}^+$; $s^+ \rightarrow m_1 + 3z_\pi + z_2$

$(m_1 + \bar{m}_2) \rightarrow \pi^+$; $m_2{}^- + 3z_\pi \rightarrow \lambda^-$; $2z_2 \rightarrow (m_1 + \bar{m}_1)$; $(\lambda^- + \bar{m}_1) \rightarrow K^-$; $\bar{\lambda}^- \rightarrow \bar{m}_2 + 3z_\pi$; $(m_1 + \bar{m}_2) \rightarrow \pi^+$

So, we have by CGT:

$$\Xi_c{}^{2+}{}_c(c^\bullet,\ c^\bullet,\ s^+) \rightarrow \Lambda_c{}^+ + K^- + 2\pi^+ + (3z_\pi + z_2) \rightarrow \Lambda_c{}^+ + K^- + 2\pi^+ + \lambda^0, \qquad (32)$$

(λ^0 –pseudo-quark). Also, it results as possible and the mass variant: $c^\wedge = 3v^\bullet$ = 3x556 = 1668 MeV/c^2.

b) *The bark's forming:*

In 1977, an experimental group at Fermilab discovered a resonance at 9.5 GeV/c^2 which was interpreted as a bottom-antibottom quark pair (the Upsilon meson), in a sample of 9000 di-muon events with a mass: $m_{\mu+\mu-}$ > 5 GeV GeV, resulting that the mass of the bottom quark is about 5 GeV/c^2.

The studied reaction was: $p_r + N \rightarrow \mu^+ + \mu^- + X$, where N was a copper or platinum nucleus, [32].

Conform to CGT's model, the b -quark (of Souza/CGT flavor) is formed by re-clusterizing from a common PD-state, resulting at two nuclei collision, conform to the mass conservation law, in accordance to the reactions (16), in the next way:

Bark: $b^- = [(c^- + \bar{c}^-) + c^-] = 2[(v^{\bullet-} + \bar{v}^{\bullet-}) + v^{\bullet-}] + [(v^{\bullet-} + \bar{v}^{\bullet-}) + \bar{v}^{\bullet-}] = 4(v^{\bullet-} + \bar{v}^{\bullet-}) + v^{\bullet-} =$

$4(p + n - m_1 + p + n - z_2)) + (n + n - m_2) = (10n + 8p) - (4m_1 + m_2 + 4z_2) = 5n_e + 3p - (4m_1 + m_2 + 4z_2) =$

$4n_e + (2n + p) + 3p - (4m_1 + m_2 + 4z_2) = 4n_e + n + (m_2 + 2z_\pi) + 4(m_1 + 2z_\pi) - (4m_1 + m_2 + 4z_2) =$

$4n_e + n + (m_2 + 2z_\pi) + 4(m_1 + 2z_\pi) - (4m_1 + m_2 + 4z_2) = 4n_e + n + (10z_\pi - 4z_2)$;

$$2n_e = (12z_\pi + 6z_2) = (84 + 24)z^0 = 108\ z^0\ ;\ \Rightarrow (10z_\pi - 4z_2) = (70\text{-}16)z^0 = 54z^0 = 6z_\pi + 3z_2 = n_e \qquad (33)$$

$\Rightarrow b^- = 4n_e + n + (10z_\pi - 4z_2) = 5n_e + n$, (~5,008 MeV/$c^2$;).

Anti-bark: $\bar{b}^- = [(c^- + \bar{c}^-) + \bar{c}^-] = 2[(v^{\bullet-} + \bar{v}^{\bullet-}) + \bar{v}^{\bullet-}] + [(v^{\bullet-} + \bar{v}^{\bullet-}) + v^{\bullet-}] = 4(v^{\bullet-} + \bar{v}^{\bullet-}) + \bar{v}^{\bullet-}$; $\Rightarrow b^- = 5n_e + \bar{n}$

The masses of the experimentally evidenced mesons: B^+(5279.34) MeV/c^2; B^0(5279.65) MeV/c^2; $B^0{}_s$(5366.88) MeV/c^2; $B^+{}_c$(6274.9) MeV/c^2, are explained in CGT with discrepancy lower than 1%, by the next structures:

- $M[B^+(b^{\bullet+}\ \bar{v}^\bullet)] = M[B^0(b^{\bullet-}\ \bar{v}^\bullet)]$ = 5287 MeV/c^2;
- $M[B^0{}_s(b^{\bullet+}n^-n^-)]$ = 5356 MeV/c^2;
- $M[B^+{}_c(c^{\bullet+}\ \bar{b}^\bullet)]$ = 6287 MeV/c^2.

It is observed that –in CGT, the particle $B^0{}_s$(5366.88) seems to be a baryon. However, the pair: (n^-n^-) is equivalent to a possible new (anti)quark: $\bar{u}^+ = (v^{\bullet-} + m_2{}^-) = (\bar{v}^{\bullet+} + z_2)$ = 626.5 MeV/c^2, resulting that: $\bar{B}^0{}_s(5356.5) = \bar{B}^0{}_s(b^{\bullet+}\ \bar{u}^+)$

or: $u^- = (v^{\bullet-} + z_2)$; $\Rightarrow B^0{}_s(5356.5) = B^0{}_s(b^{\bullet-}\ \bar{u}^-)$;

(u- 'uark' –corresponding to $k_2 = k_1 = 3$ and $f = 1$).

The neutral B_s-meson's oscillation, (a fundamental prediction of the Standard Model), is the phenomenon of B_s- mesons changing between their matter and antimatter forms before their decay. The B_s meson can exist as ($b^{\bullet-}\ \bar{u}^-$)- or ($u^{--}\ \bar{b}^\bullet$)-state.

B_s– $\bar{B}_s$ mixing was observed by the CDF experiment at Fermilab in 2006, (B_s- meson's switching between matter and antimatter 3 trillion times per second), [33].

The Standard model considers that these oscillations are mediated by the W boson and the top quark which- being heavier than the B_s– $\bar{B}_s$ mesons, they act as short lived virtual particles.

This phenomenon is in concordance to the possibility of electric charge's transferring from a $m_{1;2}$- quark to a z_π -preonic bosons or from a quark to another quark or pseudo-quark of the same particle, considered in CGT, but also to the structure of the B_s-meson, considered in CGT, in the sense that if it contains the considered new (anti)quark:

$\bar{u}^+ = (v^{\bullet-} + m_2{}^-)$, the electron which gives the negative charge of the $m_2{}^-$ -quark from its sub-structure can be transferred to the $b^{\bullet+}$ -quark which it is transformed into $b^{\bullet-}$ -quark, i.e.:

$m_2{}^- \rightarrow m_1{}^+ + w(e^- + \gamma^*)$; $\Rightarrow \bar{u}^+ \rightarrow \bar{u}^- + w^-$;

$b^{\bullet+} + w^- \rightarrow b^{\bullet-}$; $\Rightarrow \bar{B}^0{}_s \rightarrow B^0{}_s(b^{\bullet-}\ \bar{u}^-)$.

It is observed that in CGT, the B_s-quark's oscillation can be naturally explained by the weson's transferring from a quark to another inside the same particle, without the hypothesis of the top-quark's contribution.

-Conform to the resulting quark model of CGT , is possible the forming of also the next structures:

$k^+ = (2m_1 + m_2) \approx 404\ m_e$; $k^0 = (2m_2 + m_1)$;

$k^- = (2\bar{m}_1 + \bar{m}_2)$; $(3\lambda^-)$; $(3s^-)$; $(3v^-)$;

$3(\pi^+ + \pi^-) = 3m_2 + 3m_1 + 3\bar{m}_1 + 3\bar{m}_2 =$

$= (k^+ + k^0 + \bar{k}^+ + \bar{k}^0) = (k^+ + 2k^0 + k^-)$

(n + n + z^0 → $v^{\bullet -}$ + m_2 + z^0 = v^- + m_2);
The primary decay modes of J/ψ , which is: (c $\bar{c}$) → 3g ,(64.1%±1.0%), can also be explained by the conclusion that the considered gluons g are quarcic ($v^\bullet$ $\bar{v}^\bullet$) – and (s $\bar{s}$)- pairs, (mesonic pairs).

5. THE MASSES OF BARYONS AND OF MESONS IN C.G.T.

a) A general semi-empiric equation for the baryons' mass which gives a lower discrepancy between the CGT's value $\sum_1^3 m(q_k^f)$ and the experimental value, can be written by the sum rule in the form [20]:

$$m(p_b) = \sum_1^3 m(q_k^f) - \delta m_q = \sum_1^3 m(q_k^f) - (n\cdot\tfrac{1}{6}|\sum f_q| + J^p - \tfrac{1}{2})\cdot z^0 \; ; \quad (34)$$

($f = f_q = 2$; n = 0÷2 for J^p = ½ and n = 0÷5 for J^p = 3/2); $\delta m_q / m(p_b) < 2.7\%$); ($f_q$ –quark's flavor).

b) Because the pseudoscalar mesons have the total angular momentum (the total spin) J^p = 0 and the vector mesons have: J^p = 1, it can be written a semi-empiric equation similar to Eq. (34), giving a lower discrepancy between the value $\sum_1^2 m(q_k^f)$ and the experimental value, in the form [20]:

$$m(p_b) = \sum_1^2 m(q_k^f) - \delta m_q = \sum_1^2 m(q_k^f) - (n - |\sum f_q| - J^p)\cdot z^0; \quad (35)$$

$\delta m_q / m(p_m) < 5\%$); $f_q|$ = [1;2] ; n = 0÷8 for J^p = 0 and n = 0÷5 for J^p = 1; ($f_q(\bar{q}) = -f_q(q)$)

c) Eqn. (34) can explain by CGT also the Guadagnini formula [34]:

$$8(m_{\Xi^{*-}} + m_N) + 3m_\Sigma = 11m_\Lambda + 8m_{\Sigma^{*-}} \; ; \quad (36a)$$

($\Xi^* = \Xi$ (J^p = 3/2))

which is verified also by the masses of Ξ*, N, Σ, Λ - resulting in CGT: 8(1530 + 939) + 3x1192 ≈ 11x1115.36 + 8x1385; ⇒ 23328 MeV/c^2 ≈ 23349 MeV/c^2 , (satisfied with less than 1% discrepancy).

Verification: In CGT, we also have:

$$8\text{x}(2v^\bullet + \lambda^\bullet + 2n + p) + 3(v + n + p) \approx 11\text{x}(s^\bullet + n + p) + 8(v + s + n); \; (q^\bullet = q - z^0) \quad (36b)$$

$$\Rightarrow 16v^\bullet + 8\lambda^\bullet = 5v^\bullet + 11s^\bullet + 11z_2 + 8\lambda^\bullet = 5v^\bullet + 11s^\bullet + 3z_2 + 8s^\bullet = 5v + 8s + 11s^\bullet - z^0 \approx 5v + 8s + 11s^\bullet$$

So, the very low discrepancy of Eq. (36a) given by the experimental masses (Δ_M = 21 MeV/c^2) is very well explained by the CGT's model of the constituent quarks, (as $\Delta_M \approx 1z^0$ = 17.37 MeV/c^2).

It results also –by CGT, that we must have:

$$6(M(\eta^0)_e + M(\pi^0)_e) = 8M(K^0)_e + M(\pi^0)_e \quad (37a)$$

because we have –in CGT:

$3\cdot[M(\eta^0)_e + M(\pi^0)_e] = 4M(K^0)_e + M(\pi^0/2)_e$, i.e:

$$3(M_{S^\bullet} + M_m^- + 2M_m^\pm) = 3(29-1+4+8)z^0 = 120\,z^0 \approx 4(M_\lambda^- + M_m^+) + z_2 = [4(25+4)+4]z^0 \quad (37b)$$

Verification: Indeed, the experimental values of the mesons' masses verify Eq. (37a) because we have: 3(1073+273) = 4038 m_e ≈ 4(974.5) + 273/2 = 4034.5 m_e . The reaction [35]:

Ξ^- + p_r → 2Λ + 28.33 MeV. of exotic nuclei forming, results as possible in CGT, by:

(2s + n) + (2p + n) → (2s$^\bullet$ + 2z^0) + 2p + 2n ;

$$\Rightarrow \Xi^- + p_r \rightarrow 2\Lambda^0 + 2z^0 (\sim 34 \text{ MeV}), \quad (38)$$

(by: s→ s$^\bullet$ + z^0). The reaction (38) explains also the value of the released energy: 28.33 MeV.

6. CONCLUSIONS

- It results that the values of constituent quarks masses in the S.M.'s variant result by the CGT's unitary formula (11) with discrepancy under 1%, excepting the case of the u/d-quarks, which result conform to the sum rule, in CGT, (1/3 proton' mass).

-The ground state masses of the known baryons and mesons and of other multi-quarks particles can be obtained as sum of the masses of their constituent quarks, obtained by CGT with eventual some de-excited reactions, without the need of intermediary quarks obtained by the mixing of the basic quarks, (using the Cabibbo angles), or of the Higgs' bosons theory, as in the Standard Model.

- The gammonic/preonic clusters, released by excited quarks during some de-excitation reactions, are identifiable –în CGT's model, as hard gamma-quanta, conclusion that is in concordance with the known reaction: π + p → γ + n + Q_n , where the gamma ray, γ, has an energy of 129 MeV and the neutron's kinetic energy, Q_n, is 8.8 MeV, giving a total emitted energy of 137.8 MeV- close to the rest energy of the π^- -pion, (139.57018 MeV).

-The possibility to explain by CGT the heavier quarks forming from nucleonic quarks, by the forming of an intermediary 'plasmic drop' state , shows that the same reaction that explains the emission of π- and μ- mesons by nucleons explains in CGT also the formation of the chark- quark (charm-quark in the Souza/CGT mass variant), similarly being argued the validity of the bark-quark's mass, (~5 GeV/c^2 – in the Souza/CGT variant), in concordance to the conclusion [36] that the J/ψ meson production (which contains c$^\bullet$-quarks) may be a 'smoking gun' observable for the diagnosis of the Quark-Gluon Plasma (QGP) produced in ultra-relativistic nucleus-nucleus collisions.

-The differences Δ^γ between the masses of particles (mesons or baryons) of the same multiplet but having different electric charges can be also explained by the mass(es) of clusters of linking gammons of square, pentagonal, hexagonal or cubic form: $(2^2 \div 3^2)\gamma^*$ or $(2^3 \div 3^3)\gamma^*$, ($m(\gamma^*) = 2m_e^* = 1.62\, m_e \approx 0.828$ MeV/c^2) formed/acquired by the particles having the charge $e^\pm$ or $2e^\pm$- given by degenerate electron(s) which is/are linked to the particle's neutral cluster by a such gammonic cluster, (which can be considered pseudo-gluons, in this case), in accordance to the Dashen's relation: $\Delta^{\gamma}(\pi^{\pm}) \approx \Delta^{\gamma}(K^{\pm})$, [37].

For example, the difference $\Delta_{\pi} \approx 4.6$ MeV/c^2 between the masses of the light mesons $\pi^0 = 134.97$ MeV/c^2 and $\pi^- = 139.57$ can be explained by a quatruplet $\gamma^{4*} = 4\gamma^* = 4x0.828 = 3.31$ MeV/c^2 and the difference $\Delta_K \approx 3.95$ MeV/c^2 between the masses of the K-mesons: $K^0 = 497.61$ MeV/c^2 and $K^{\pm} = 493.67$ can be explained by a quintet: $\gamma^{5*}= 5\gamma^* = 4.14$ MeV/c^2.

-Also, the model can explain naturally the Gell Mann-Oakes-Renner relation.

-A relative correspondence with the S.M.'s quark model results by a Copenhagen-like quantum vacuum, (with vortices), if we suppose that all mass of the z^0-preon's degenerate electrons, e*, is contained by their kerneloids and that a layer of 7e*(2.9MeV) represents a current u_c- quark, the valence d_c-quark being a gluonic $g(u_c\bar{u}_c)$-pair with an e^{*-} replaced by an electron, e, fixed in the top of constituent d-quark.

Refrences

[1] Patrignani, C. et al. (Particle Data Group), 2016, "Quarks", Chin. Phys. C., 40, 100001

[2] Andersson, B., Gustafson, G., Ingelman, G., Sjöstrand, T. 1983. "Parton fragmentation and string dynamics". Phys. Rep. 97 (2–3) 31–145

[3] B. Silvestre-Brac, 1992, "Systematics of Q2(□Q2) systems with a chromo-magnetic interaction". Phys. Rev. D 46, 2179

[4] Bevelacqua, J.J., 2019, "A First-Order Mass Formula for Quarks in Terms of Constituent Preons". J. of Nucl. and Particle Physics, 9, 1-4

[5] de Souza, M. E., 2011, "Calculation of almost all energy levels of baryons".Papers in Physics, vol. 3, art. 030003

[6] de Souza, M.E., 2008, "Weak decays of hadrons reveal compositeness of quarks", Scientia Plena. 4 (6): 064801–1.

[7] Arghirescu M., 2006, "The Material Structures Genesis and Fields Effects", Ed. MatrixRom, Bucharest. RO

[8] Arghirescu, M., 2015, "The Cold Genesis of Matter and Fields", (Science P.G.). viXra:1104.0043

[9] Arghirescu M. ,2016, "A preonic quasi-crystal quark model based on a cold genesis theory and on the experimentally evidenced neutral boson of 34 me" Global J. of Phys., 5 (1) 496-504

[10] Arghirescu M., 2018, "A model of particles cold forming as collapsed Bose–Einstein condensate of gammons", PAIJ, 2 (4): 260-267.

[11] Sarri G., Poder K., Cole J., et al., 2015, "Generation of neutral and high-density electron– positron pair plasmas in the laboratory",Nature Communication, 6: 6747, 23

[12] Hellman Olavi, 1961, "A proposed elementary particle theory based on interacting classical fields", Turun Yliopisto, Turku, (preprint).

[13] Krasznahorkay A..J. et al., 2016, "Observation of Anomalous Internal Pair Creation in 8Be: A Possible Signature of a Light, Neutral Boson," Phys. Rev. Lett. 116(4):042501. arXiv: 1504.01527v1, [nucl-ex] 2015

[14] Cockroft, J. D., 1964, "Experiments on the interaction of high-speed nucleons with atomic nuclei", Nobel Lectures, 11 Dec. (1951). Elsevier Pub. Comp., Amsterdam

[15] Arghirescu, M., 2021, "An Explanatory Model of Heavy Quarks and Particles Generating resulted by a Cold Genesis Theory", Theor. Phys. Lett., 9 (11): 190-217

[16] Maiani, L., 2002, "Lecture 2: Exotic Hadrons. The constituent Quark Model", Galileo Galilei Inst., Firenze, IT. arXiv: 2207.05141

[17] M. Karliner, J. L. Rosner, 2014, "Baryons with two heavy quarks: Masses, production, decays and detection", Phys.Rev. D90, 094007. arXiv:1408.5877 [hep-ph].

[18] Carrigan R. A. Jr., 1978, "Compound Quarks as an Explanation for the Apparent Quark Mass Spectrum", Fermi Nat. Accelerator Lab., Batavia, Illinois, 60510.

[19] Arghirescu, M. ,2024, „The Structure and the Density of a Bare Quark Star in a Cold Genesis Theory of Particles". J. of High Energy Physics , Gravitation and Cosmology , 10, 1933-1980.

[20] Arghirescu M., 2023, "Quarks species in a cold genesis theory; theoretic implications of a vortical quark model", Phys Astron Int J. 7(3):195–207

[21] Gell-Mann, M., Oakes, R. J., Renner B., 1968, "Behavior of Currents Divergences under SU3xSU3". Phys Rev. 175 2195

[22] E. Iancu, A. Leonidov, L. McLerran, 2001, Nucl. Phys. A692, 583; Phys. Lett. B 510 133

[23] E. Ferreiro, E. Iancu, A. Leonidov, L. McLerran, 2002, Nucl. Phys. A 703 489.

[24] Bjorken, J. D., 1968, "Current Algebra at Small Distances", in Proceedings of the International School of Physics Enrico Fermi . Course XLI, J. Steinberger, ed., Acad. Press, New York, pp. 55-81.

[25] F. Gelis, E. Iancu, J. Jalilian-Marian, Raju Venugopalan, 2010. Ann. Rev. Nucl. Part. Sci. 60, 463-489. [arXiv:1002.0333 [hep-ph]

[26] G. Soyez, 2007, „Saturation QCD predictions with heavy quarks at HERA", Phys. Lett. B 655, 32

[27] Perl, M.L.; Abrams, G.; Boyarski, A. et al., 1975, "Evidence for anomalous lepton production in e+e−annihilation". Phys. Rev. Lett. 35 (22): 1489.

[28] Thews, R. L.; Schroedter, M.; Rafelski, J., 2001, "Enhanced J/ψ production in deconfined quark matter." Phys. Review C. 63 (5): 054905. arXiv:hep-ph/0007323

[29] LHCb Collaboration, 2020, "Observation of structure in the J/ψ-pair mass spectrum", Science Bulletin 65, 1983. arXiv: 2006.16957 [hep-ex].

[30] M. A. Bedolla et al., 2020, "Spectrum of fully-heavy tetraquarks from a diquark+antidiquark perspective", Eur. Phys. J. C 80 1004. arXiv: 1911.00960 [hep-ph]

[31] The ATLAS Collaboration (CERN), 2023. "Observation of an excess of dicharmonium events in the four-muon final state with the ATLAS detector", Phys. Rev. Lett. 131,151902 CERN-EP-2023-035

[32] S.W. Herb, E288 Collaboration, 1977, "Observation of a Dimuon Resonance at 9.5-GeV in 400-GeV Proton-Nucleus Collisions", Phys.Rev.Lett. 39 (1977) 252-255

[33] Press release, 2006, 25 Sept., Fermilab.

[34] E. Guadagnini, 1984, "Baryons as solitons and mass formulae." Nucl. Phys. B, 236 (1) 35-47

[35] Yoshinori Akaishi, 1999, "Light Hypernuclei and Exotic Atoms", Proc. of the Symposium on Frontier Nucl. Phys. (FRONP99) Aug. 2-4 , Jaeri, Tokai, Japan

[36] T. Matsui, H. Satz, 1986. Phys. Lett. B 178 416

[37] R. Dashen, 1969, "Chiral SU(3)□SU(3) as a Symmetry of the Strong Interaction", Phys. Rev. 183,1245.