An alternative model of particle composition?

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Abstract: A phenomenological model developed independently of most of the recent theoretical concepts is presented and its properties are briefly described.

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In this contribution the result of an attempt to formulate a model of particle composition and interactions on the basis of a few very simple fundamental assumptions is described. The goal was to find, if possible, a simpler and more general description of the known facts.

Basic assumptions of the model are the following:

1) There are four fundamental components of particles: A^{++}, B^{+-}, C^{--}, D^{-+}, where the superscripts belong to the electric charge Q and the baryon number B. Their values are $\pm½\ \varepsilon$, where ε is the electric charge of the positron, and $\pm½\ \beta$, where β is the baryon number unit.

2) Each particle is composed of a certain number of the four fundamental components. In all decays and interactions the total number of components of each kind is strictly conserved.

The composition of a particle can be expressed as [*abcd*], where *a* is the number of components A^{++}, *b* the number of B^{+-}, etc. The charges Q and B of a particle are thus:

$$Q = ½\ (a+b-c-d) \quad \text{and} \quad B = ½\ (a-b-c+d). \tag{1}$$

The total number of components of each particle is always even. The sum $s = a+b+c+d$ can thus be 2, 4, 6, etc. One can expect that the pairs of components are fermions with spin ½ $\hbar$ and that the bosons are composed of an even number of such pairs. Hence, for fermions *s* can be 2, 6, 10, etc., and for bosons 4, 8, 12, etc.

The conservation law can be expressed as:

$$\Sigma a_L = \Sigma a_R\ ,\ \Sigma b_L = \Sigma b_R\ ,\ \Sigma c_L = \Sigma c_R\ ,\ \Sigma d_L = \Sigma d_R\ , \tag{2}$$

where the sum is over all the particles entering (at the left side) and outgoing (at the right side) the process.

3) There exist neutral field bosons (or background bosons) *E*, *W* and $\tilde{W}$ with negligible masses, energies and momenta, which participate in the interactions. *E* enters the electromagnetic and strong processes and *W* or $\tilde{W}$ enters the weak processes. Higher order (less probable) processes are those with the participation of *EE, EEE,* etc., or *WE*, $\tilde{W}E$, *WEE*, $\tilde{W}EE$, etc., respectively. The compositions of the three background bosons are:

$$E \equiv [1111],\ W \equiv [2020], \text{ and } \tilde{W} \equiv [0202]. \tag{3}$$

Possible compositions of particles for the lowest *s* values (limited to charges 0, ±1) are presented in Table 1. The shown assignments of individual compositions to known particles (limited to “ordinary” leptons, mesons, and baryons; the taon has been added later) were obtained after some investigation and computer experiments, for which the input data was a list of all observed decay modes with their branching ratios. All data used in this investigation (particle masses, decay modes and their branching ratios) were taken from ref. [1].

Table 1 Compositions [*abcd*] of particles and their assignments

	Q=+1	Q=0	Q=0	Q=–1		Q=+1	Q=0	Q=0	Q=–1
s=2, B=0 leptons	1100 e^+	1010 ν_μ	0101 $\tilde{\nu}_\mu$	0011 e^-	s=6, B=±1 baryons	4020 —	—	—	2040 —
s=4, B=0 mesons	1201 π^+	1111 π^0	1111 γ	1021 π^-		1311 $\tilde{\Sigma}^+$	1221 $\tilde{\Sigma}^0$	2112 Σ^0	2022 Σ^-
	2110 K^+	2020 K^0	0202 $\tilde{K}^0$	0112 K^-		2202 Σ^+	2112 Λ	1221 $\tilde{\Lambda}$	1131 $\tilde{\Sigma}^-$
s=6, B=0 leptons	1302 μ^+	1212 $\tilde{\nu}_e$	2121 ν_e	2031 μ^-		2220 $\tilde{\Xi}^+$	2130 $\tilde{\Xi}^0$	1203 Ξ^0	1113 Ξ^-
	2211 —	2121 —	1212 —	1122 —		3111 p	3021 n	0312 $\tilde{n}$	0222 $\tilde{p}$
	3120 τ^+	3030 $\tilde{\nu}_\tau$	0303 ν_τ	0213 τ^-		0402 —	—	—	0204 Ω^-

With the list of decay modes in its initial version the optimal particle assignment found matched only 68 of the 92 decay modes. All of the remaining 24, which were rejected, turned out to be decays with the emission of neutrinos. A remarkable improvement was achieved by carrying out the transformations $\nu_\mu \leftrightarrow \tilde{\nu}_\mu$ or $\nu_e \leftrightarrow \tilde{\nu}_e$ in all of those 24 decay schemes. After this transformation, surprisingly, all 92 decay schemes (excluding those 24 original and including those 24 altered) were found to be in agreement with the estimated optimal particle assignment, i.e. for every one of the 92 decay modes the conservation law of eq. (2) was found to be fulfilled. As an example, the main decay mode of the neutron is:

$$\begin{matrix} \tilde{W} & & E & & n & \rightarrow & p & & e^- & & \tilde{\nu}_e \\ [0202] & + & [1111] & + & [3021] & = & [3111] & + & [0011] & + & [1212]. \end{matrix} \tag{4}$$

A study of possible decays indicates that the conservation law (2) is too permissive and that additional limiting rules are necessary. There is, however, possible to formulate them and together with the multiplicative conservation laws to get the desired selection. It turns out that the *E* boson has a limited ability to split and pass its components to the particles formed in the decay and that therefore some kinds of regrouping of components can occur only when triggered by a W or $\tilde{W}$ boson. The lepton number conservation law does not follow from the model but the empirical consequences of it seem to be of little significance.

A surprising affinity between the quark model and this new 4-component- or 4C model was found. Individual light quarks d, u, s and antiquarks $\tilde{d}, \tilde{u}, \tilde{s}$ can be expressed as linear combinations of the 4C model components. The transformation is:

$$\begin{aligned} d &= A + C - \tfrac{1}{3} B + \tfrac{1}{3} D \\ u &= A + \tfrac{2}{3} B + \tfrac{1}{3} D \\ s &= \tfrac{2}{3} B + 4/3\, D \\ \tilde{d} &= 4/3\, B + \tfrac{2}{3} D \\ \tilde{u} &= C + \tfrac{1}{3} B + \tfrac{2}{3} D \\ \tilde{s} &= A + C + \tfrac{1}{3} B - \tfrac{1}{3} D. \end{aligned} \qquad (5)$$

With the help of these equations the quark compositions of all seven mesons, nine baryons and eight antibaryons listed in Table 1 can be transformed to their correspondent 4C compositions as listed in the same table. As an example, for the proton one gets:

$$p \equiv u+u+d = 2(A + \tfrac{2}{3} B + \tfrac{1}{3} D) + A + C - \tfrac{1}{3} B + \tfrac{1}{3} D = 3A + B + C + D \equiv [3111] \qquad (6)$$

The inverse transformation is likewise possible:

$$\begin{aligned} A &= u - \tfrac{1}{2} \tilde{d} \\ B &= \tilde{d} - \tfrac{1}{2} s \\ C &= \tilde{u} - \tfrac{1}{2} s \\ D &= s - \tfrac{1}{2} \tilde{d} \end{aligned} \qquad (7)$$

but the expressions in eq. (7) are not unique due to the fact that the properties of the six quarks are not independent quantities; they are interrelated by the formula

$$d + \tilde{d} = u + \tilde{u} = s + \tilde{s} = A + B + C + D \equiv [1111]. \qquad (8)$$

With the help of eq. (7) and (8) the quark compositions of mesons and baryons can be obtained from the 4C model compositions. The equations (5) and (7) transform also correctly the correspondent properties of quarks (±⅓ and ±⅔ charges) to those of the 4C components (±½ charges) and vice versa. Hence, the two models are mathematically equivalent.

The particle-antiparticle inversion found with the help of the quark model is:

$$[abcd] \leftrightarrow [\tfrac{1}{2}s-a, \tfrac{1}{2}s-b, \tfrac{1}{2}s-c, \tfrac{1}{2}s-d], \qquad (9)$$

where s is the total number of components of the particle. Such inversion can be understood in terms of the 4C model only by concluding that the two charges (Q and B) are not the only properties of the four components and that at least one more “charge” has to be ascribed to them. Straightforward candidates are the quark flavors S and I_z. With them we get

$$
\begin{aligned}
A &\equiv [1000] = \{\ \tfrac{1}{2}\ \ \tfrac{1}{2}\ \ 0\ \ \tfrac{1}{4}\} \\
B &\equiv [0100] = \{\ \tfrac{1}{2}\ {-\tfrac{1}{2}}\ \ \tfrac{1}{2}\ \ \tfrac{1}{2}\} \\
C &\equiv [0010] = \{-\tfrac{1}{2}\ {-\tfrac{1}{2}}\ \ \tfrac{1}{2}\ {-\tfrac{1}{2}}\} \\
D &\equiv [0001] = \{-\tfrac{1}{2}\ \ \tfrac{1}{2}\ \ 1\ {-\tfrac{1}{4}}\}
\end{aligned} \tag{10}
$$

where for each component the four "charges" are shown. For each particle one gets

$$S = \tfrac{1}{2}\, b + \tfrac{1}{2}\, c - d \quad \text{and} \quad I_z = \tfrac{1}{4}\, a + \tfrac{1}{2}\, b - \tfrac{1}{2}\, c - \tfrac{1}{4}\, d. \tag{11}$$

The inversion applied changes the signs of all the charges. The simplest invertible pairs of components which in the 4C model replace the quarks are the following:

$$
\begin{aligned}
c &\equiv CD \equiv [0011] = \{-1\ \ 0\ {-\tfrac{1}{2}}\ {-\tfrac{3}{4}}\} \\
\tilde{c} &\equiv AB \equiv [1100] = \{\ 1\ \ 0\ \ \tfrac{1}{2}\ \ \tfrac{3}{4}\} \\
n &\equiv BD \equiv [0101] = \{\ 0\ \ 0\ {-\tfrac{1}{2}}\ \ \tfrac{1}{4}\} \\
\tilde{n} &\equiv AC \equiv [1010] = \{\ 0\ \ 0\ \ \tfrac{1}{2}\ {-\tfrac{1}{4}}\} \\
b &\equiv AD \equiv [1001] = \{\ 0\ \ 1\ {-1}\ \ 0\} \\
\tilde{b} &\equiv BC \equiv [0110] = \{\ 0\ {-1}\ \ 1\ \ 0\}.
\end{aligned} \tag{12}
$$

One can introduce their identification as $c, \tilde{c}$ (charged), $n, \tilde{n}$ (neutral), and $b, \tilde{b}$ (baryonic). There exist four other pairs of fundamental components, namely *AA*, *BB*, *CC*, and *DD*, but they are not invertible in the above-given sense.

The pair (*pp*) and quark (*qq*) compositions of the "ordinary" particles with the sets of their "charges" are shown in Table 2. At the first glimpse it seems impossible to accept the idea that the pairs c, $\tilde{c}$ and n, $\tilde{n}$ are the constituents of both the light particles like electrons and neutrinos, and the heavy ones like mesons and baryons. It could be understood, however, if one would assume that these fermions exist at least in two different mass states: a "leptonic" and a "hadronic" one, and that the transition between them can be accomplished only by an "intermediate boson" W or $\tilde{W}$. Also the charmed and bottomed hadrons do not seem to require the introduction of new entities but their existence can be explained in a similar way.

The 4C model correctly predicts all leptons and hadrons in their proper number but minor differences exist and they can be used for experimental tests of it. The particle Ω^- appears to be non-invertible and hence $\tilde{\Omega}^+$ can exist only as a penta-pair structure $\tilde{b}\tilde{c}\tilde{n}\tilde{n}\tilde{n}$. Also the baryon Δ^- (*ddd*) can in 4C exist only as a penta-pair $bc\tilde{n}\tilde{n}\tilde{n}$. On the other hand, the 4C model predicts the particle X^+ [4020] ≡ {1 1 1 0} with $S = +1$ which in the quark model could exist only as a pentaquark $uudd\tilde{s}$. Other differences can be found among baryons with $Q = \pm 2$. The 4C unlike the quark model permits also mesons with $B = \pm 1$ and hyperons with $B = \pm 2$.

As seen from Table 2, the flavor I_z does not make sense for leptons. Since the position of particles is established by their composition, this flavor seems to be redundant.

Table 2. The composition of particles presented as a set of invertible pairs of the fundamental 4C components (*pp*). The quark composition (*qq*) is also shown. For hadrons the values of "charges" (flavors) are the same for both *qq* and *pp* compositions.								
No.	P.	*pp*	*qq*	Q B S I_z	Ap.	*pp*	*qq*	Q B S I_z
1	$\tilde{\nu}_\mu$	*n*		0 0 –½ ¼	ν_μ	*ñ*		0 0 ½ –¼
2	e^-	*c*		–1 0 –½ –¾	e^+	*c̃*		1 0 ½ ¾
3	π^0	*nñ*	*uũ*	0 0 0 0	γ, E	*ñn*	*ũu*	0 0 0 0
4	π^-	*cñ*	*ũd*	–1 0 0 –1	π^+	*c̃n*	*ud̃*	1 0 0 1
5	K^-	*cn*	*ũs*	–1 0 –1 –½	K^+	*c̃ñ*	*us̃*	1 0 1 ½
6	$\tilde{K}^0$,$\tilde{W}$	*nn*	*d̃s*	0 0 –1 ½	K^0,W	*ññ*	*ds̃*	0 0 1 –½
7	$\tilde{\nu}_e$	*nnñ*		0 0 –½ ¼	ν_e	*ññn*		0 0 ½ –¼
8	$\tilde{\nu}_\tau$	*nnn*		0 0 –$^3/_2$ ¾	ν_τ	*ñññ*		0 0 $^3/_2$ –¾
9	μ^-	*cññ*		–1 0 ½ –$^5/_4$	μ^+	*c̃nn*		1 0 –½ $^5/_4$
10		*cnñ*		–1 0 –½ –¾		*c̃ñn*		1 0 ½ ¾
11	τ^-	*cnn*		–1 0 –$^3/_2$ –¼	τ^+	*c̃ññ*		1 0 $^3/_2$ ¼
12	*p*	*bc̃ñ*	*uud*	1 1 0 ½	*p̃*	*b̃cn*	*ũũd̃*	–1 –1 0 –½
13	*n*	*bññ*	*udd*	0 1 0 –½	*ñ*	*b̃nn*	*ũd̃d̃*	0 –1 0 ½
14	Λ	*bnñ*	*uds*	0 1 –1 0	$\tilde{\Lambda}$	*b̃ñn*	*ũd̃s̃*	0 –1 1 0
15	Σ^+	*bc̃n*	*uus*	1 1 –1 1	$\tilde{\Sigma}^-$	*b̃cñ*	*ũũs̃*	–1 –1 1 –1
16	Σ^0	*bnñ*	*uds*	0 1 –1 0	$\tilde{\Sigma}^0$	*b̃ñn*	*ũd̃s̃*	0 –1 1 0
17	Σ^-	*bcñ*	*dds*	–1 1 –1 –1	$\tilde{\Sigma}^+$	*b̃c̃n*	*d̃d̃s̃*	1 –1 1 1
18	Ξ^0	*bnn*	*uss*	0 1 –2 ½	$\tilde{\Xi}^0$	*b̃ññ*	*ũs̃s̃*	0 –1 2 –½
19	Ξ^-	*bcn*	*dss*	–1 1 –2 –½	$\tilde{\Xi}^+$	*b̃c̃ñ*	*d̃s̃s̃*	1 –1 2 ½
20	Ω^-	*DDnn*	*sss*	–1 1 –3 0	$\tilde{\Omega}^+$		*s̃s̃s̃*	1 –1 3 0

The 4C model appears to be more general (it unites leptons and hadrons) and simpler (it works with only four components) than the quark model. Since strangeness of the weak field bosons is ±1 and since also the leptons have strangeness, its seeming non-conservation in weak decays can be easily explained.

More detailed description of this concept can be found in ref. [2].

References

[1] Yao, W.-M. et al.: (Particle Data Group), J. Phys., G 33 (2006).

[2] Kajfosz, J.: http://www.heureka.nd.pl/4C-QQ.pdf .