Letters to the Editor

On a Rational System of Symbols for Fundamental Particles

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According to the latest investigations* on the systematics of the elementary interactions, there are four fundamental parameters. These parameters E, n, s and ν determine the type of the process for the formation and decay of the elementary particles, as well as the place of the particles in the natural systematics shown in Table I**. Here $E = Q/e$ is the difference between the positive and negative charges; n is the difference between the number of heavy particles (barions) and heavy antiparticles (antibarions), or the "nuclear charge"***[4-6]; s is the "strangeness"[1] or v is the charge[7]; ν is the difference between the number of light particles (leptons) and light antiparticles (antileptons), or the "neutrinic charge"***[8,9].

The number n, as well as E, is conserved in all the known reactions, and its conservation implies a certain absolute law on the conservation of the number of barions. The number s is conserved only in strong electromagnetic interactions, and can change by a unit in the weak interactions of the slow decay of a hyperon or of a heavy meson[1,7]. Instead of s, one can use some other number, subject to the same rules: the "neutronic charge" ϵ[2,3], the "attribute" a[11] or the projection μ_3 of the μ-isotopic spin[12].

We have shown[2] that the numbers s, ϵ, a, μ_3 and the projection τ_3 of the usual isotopic spin have the following relationship:

$$\varepsilon + E = s + n = -a = 2\mu_3; \tag{1}$$

$$E = \mu_3 + \tau_3, \quad \varepsilon = \mu_3 - \tau_3;$$

$$\tau_3 = {}^1/_2 (E - \varepsilon), \quad \mu = {}^1/_2 (E + \varepsilon).$$

It has also been shown[2] that the quantity ϵ can indeed be considered as analogous to the electric charge; this is why we think it is rational to use this quantity rather than s, a or μ_3.

The conservation of the number ν expresses the conservation of the number of leptons, in analogy with the fact that the conservation of N expresses the conservation of the number of barions. It is possible (as assumed in Ref. 9), that the conservation of the number ν is also an absolute conservation law. This point is also discussed in Ref. 13.

It is worthy noting that the names "nuclear charge" for the quantity n and "neutrinic charge" for the quantity ν can be justified only by the fact that some integers are conserved, in analogy to the conservation of the electric charge. However, there are so far no bases to believe that the nuclear and the neutronic "charges" create any fields in analogy to the electric charge. Therefore, the term "charge" for the quantities n and ν should be used purely in a conventional sense. The best way to name the quantities E, ϵ, n and ν is therefore: E = electric number, ν = neutronic number, n = barionic number, $\lambda = -\nu$ is the leptonic number.

The numbers E, ϵ, n and λ determine the place of the particle in the schematics, its basic properties, and its allowed formation and decay reactions; it is therefore rational to introduce these numbers into the symbols describing the elementary particles. We propose to write the numbers E, ϵ, n and λ as indices of the symbol Z of the particles, according to the scheme

$$ {}^{\lambda}_{n} Z^{E}_{\varepsilon} \tag{2}$$

When a reaction is described, the indices (λ, n) on the left-hand side could be confused with the indices on the right-hand side. To avoid this, we will denote the latter ones by the signs + and −, and the former ones by the signs 1 and −1. In the case where any of the numbers is equal to zero, the corresponding place will be left blank. If we chose for the barions and for the mesons the numbers E, ϵ and n as they should according to Refs. 1 and 2, and chose for the leptons the number according to Ref. 9 ****, we get Table II instead of Table I.

The symbolism of Table II presents several advantages over that of Table I. For instance, to write all the possible reactions for the formation of particles, satisfying the condition $\Delta\epsilon = 0$ (or $\Delta s = 0$) it is sufficient to require that the sum of the

TABLE I

γ	
ν e^-	$\tilde{\nu}$ e^+
μ^+	μ^-
$\pi^+ \; \pi^0 \; \pi^-$	
$k^+ \; k^-$ $k^0 \; \tilde{k}^0$	
p n	$\tilde{p}$ $\tilde{n}$
Λ^0	$\tilde{\Lambda}^0$
$\Sigma^+ \; \Sigma^0 \; \Sigma^-$	$\tilde{\Sigma}^- \; \tilde{\Sigma}^0 \; \tilde{\Sigma}^+$
Ξ^- Ξ^0	$\tilde{\Xi}^+$ $\tilde{\Xi}^0$

TABLE II

γ	
${}^{-1}\nu$ ${}^{-1}e^-$	${}^{1}\nu$ ${}^{1}e^+$
${}^{-1}\mu^+$	${}^{1}\mu^-$
$\pi^+_- \; \pi \; \pi^-_+$	
$k^+ \; k^-$ $k_+ \; k_-$	
${}_1p^+$ ${}_1n_+$	${}_{-1}p^-$ ${}_{-1}n_-$
${}_1\Lambda$	${}_{-1}\Lambda$
${}_1\Sigma^+_- \; {}_1\Sigma \; {}_1\Sigma^-_+$	${}_{-1}\Sigma^-_+ \; {}_{-1}\Sigma \; {}_{-1}\Sigma^+_-$
${}_1\Xi^-$ ${}_1\Xi_-$	${}_{-1}\Xi^+$ ${}_{-1}\Xi_+$

indices of any type, on the right or on the left, be identical; e.g.,

$$ {}_1p^+ + {}_1p^+ \to \Lambda + k^+ + {}_1p^+, $$
$$ {}_1p^+ + {}_1p^+ \to {}_1\Sigma^+_- + k_+ + {}_1p^+; $$
$$ \pi^-_+ \, {}_1p^+ \to {}_1\Lambda + k_+, $$
$$ \pi^-_+ + {}_1n_+ \to {}_1\Xi^- + k_+ + k_+. $$

and it is obvious that the reaction

$$ {}_1n_+ + {}_1n_+ \to {}_1\Lambda + {}_1\Lambda $$

is forbidden, because $\Delta\epsilon = -2$.

In the case of the slow decays of hyperons or mesons, in which $\Delta\epsilon = \pm 1$, we have, for instance,

$$ {}_1\Xi^- \to {}_1\Lambda + \pi^-_+, \quad {}_1\Xi_- \to {}_1\Lambda + \pi, $$
$$ {}_1\Sigma^+_- \to {}_1p^+ + \pi, \quad {}_1\Sigma^-_+ \to {}_1n_+ + \pi^-_+, $$
$$ {}_1\Sigma^+_- \to {}_1n_+ + \pi^+_-, $$
$$ {}_1\Lambda \to {}_1p^+ + \pi^-_+, \quad {}_1\Lambda \to {}_1n_+ + \pi, $$
$$ k^+ \to \pi^+_- + \pi, \quad k_+ \to \pi^+_- + \pi^-_+, $$
$$ \pi^+_- \to {}^{-1}\mu + {}^{1}\nu, $$
$$ {}_1n^+ \to {}_1p^+ + {}^{1}e^- + {}^{-1}\nu. $$

It is easy to see that the not yet discovered particles could be the following: 1) heavy mesons M^+_+ and M^-_- (these particles were predicted[1,2,10] or identified with the τ-mesons[12]); 2) barions or antibarions B^+_+, ${}_1B^-_-$, ${}_{-1}B^-_-$, ${}_{-1}B^+_+$ (these particles were predicted[1]); 3) leptons (analogous to all the possible barions).

All these supposedly possible particles have the quantum numbers equal to -1, 0 or $+1$ as the discovered particles.

We consider that the proposed symbolism reflects better than any other the main features of the natural system.

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* See, e.g., Refs. 1 and 2.

**In this Table all the heavy mesons are denoted by a single symbol k. It is assumed (as in Ref. 1) that the θ-and τ-mesons differ only by their spin and their parity, but have the same numbers E and s. This Table also does not allow for the possibility of the existence of two types of π^0-mesons[3].

*** In our previous papers[2,3,10], the terms "nuclear" or "neutrinic" charges were used for the numbers $N = -12$. However, the term "nuclear charge" is usually reserved to the number n.

**** In Ref. 9, the value $\epsilon = 0$ is assigned to all the discovered leptons; this is not the only possibility.

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