DIAGRAMS FOR PROCESSES INVOLVING HYPERONS*

J. Tiomno

Centro Brasileiro de Pesquisas Físicas

and

Faculdade Nacional de Filosofia

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The success of Gell-Mann model[1] in providing a scheme for a rational classification of hyperons and their reactions has been reinforced by the experimental verification of many of its predic tions.

In this theory quantum numbers are atributed to the states of the particles, which are algebrically additive and which are conserved in the "strong" and electromagnetic interactions but which may not be conserve in "weak" interactions. They are:

1) The number of particles N which assume the value +1 for a particle, -1 for an antiparticle and 0 for bosons and is assumed to be always conserved.

2) The z component of the isotopic spin (I_z), which assume values $\pm\frac{1}{2}$ for spin $\frac{1}{2}$ particles and antiparticles and 0, 1, -1 for

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spin 0 or 1 bosons.

3) The strangeness quantum number S which may assume values -2, -1, 0, +1, +2 for particles and antiparticles.

For the antiparticle corresponding to a given particle all these quantum numbers change sign.

The connection between these quantum numbers and the charge looks somewhat arbitrary:

$$Q = I_3 \text{ for isotopic } 0 \text{ or } 1$$
$$Q = I_3 \pm \frac{1}{2} \text{ for isotopic spin } \frac{1}{2} \qquad (1)$$

A more general expression for the relation between Q and the referred quantum numbers is the following[2]

$$Q = I_3 + \frac{I}{2} (S + N). \qquad (2)$$

Relations (1) and (2) have been given a physical meaning by D'Espagnat and Prentki[3] who introduced another additive quantum number U, the number of isoparticles which is 0 for integer isotopic spin particles and + 1 or -1 for $\frac{1}{2}$ isotopic spin particles. This quantum number U also changes sign by hole-conjugation. By imposing that the Lagrangean for all the strong interactions between the particles described by the Gell-Mann scheme should be invariant under rotations and symmetry operations in the isotopic spin space they have been able to assign values of U to all isotopic spin $\frac{1}{2}$ particles[4].

Table I gives Gell-Mann assignements of I, I_3, N, Q and S for the well established cases and also the form of the dependence of Q on I_3.

$$Q = Q(I_3).$$

In the eighth column the values of U are given as determined by D'Espagnat and Prentki. We should also mention that they have shown that the general relation holds

$$Q = I_3 + \frac{U}{2} \tag{3}$$

which justify the several forms of dependence of Q on I_3 in table I.

They have shown also that the strangeness S is given by

$$S = U - N . \tag{4}$$

This, together with (3) justifies equation (2).

Here we wish to emphasize the advantage of the use of the quantum number system (N, Q, U) instead of the other previously used. From the relations (2), (3) and (4) it is clear that the systems which have been used up to here:

Table I - Quantum numbers of different particles and their representation in the graphs. For the antiparticles one should charge the sign of I_3, U, Q, S and U also change the sign of the constant in the relation Q (I_3), and reverse the direction of the arrows in the graphs.

Particle	I	I_3	N	Q	$Q(I_3)$	S	U	Graph
(P, N)	$\frac{1}{2}$	$(\frac{1}{2}, -\frac{1}{2})$	1	(1, 0)	$I_3 + \frac{1}{2}$	0	1	— · → ——→
Λ	0	0	1	0	I_3	-1	0	——→
$\Sigma^+ \Sigma^0 \Sigma^-$	1	(1, 0, -1)	1	(1, 0, -1)	I_3	-1	0	——→
$\Xi^0 \Xi^-$	$\frac{1}{2}$	$(\frac{1}{2}, -\frac{1}{2})$	1	(0, -1)	$I_3 - \frac{1}{2}$	-2	-1	←— · — ——→
π^+, π^0, π^-	1	(1, 0, -1)	0	(1, 0, -1)	I_3	0	0	- - - -
Θ^+, Θ^0	$\frac{1}{2}$	$(\frac{1}{2}, -\frac{1}{2})$	0	(1, 0)	$I_3 + \frac{1}{2}$	1	1	— · →
γ	0	0	0	0	0	0	0	∿∿

(I_3, N, S), (I_3, N, Q), (I_3, Q, S), (N, Q, S)

as well as the systems

(N, Q, U), (I_3, N, U), (I_3, U, S), (I_3, U, Q), (N, U, S), (Q, S, U)

are all equivalent. (We do not include the total isotopic spin I because we are considering only the additive quantum numbers). However the simplest one is (N, Q, U) because the quantum numbers N, Q, U for one particle acquire only three values 0, + 1 or -1, in opposition to I_3 and S which have five possible values[4]. Another advantage is that Q and N are always conserved and only U may not be conserved in weak interactions (this is surely not an advantage of (N, Q, U) over (N, Q, S) and N, Q, I_3).

Finally we wish to propose a generalization of Feynman diagrams which we think is very suggestive for the representation of reactions involving hyperons. This is based on the fact that the quantum numbers N, Q, and U are additive and may assume only the values + 1, -1 or 0. Indeed it is this property which allows us to use in Feynman diagrams an arrow in the direction of time propagation for particles (N = 1), in the oposite direction for antiparticles and no arrow for bosons (N = 0).

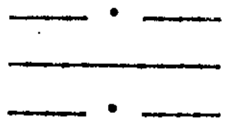
The conservation law for the number of particles assures us that a particle line can be followed from one end to the other without being interrupted or without reversal of orientation of the arrows. In the same way we can follow the charge or an isoparticle line if we use arrows in the direction of propagation for values +1, in the opposite direction for values -1 or no arrow for the value 0 of these constants of motion.

If we take the direction of increasing time from left to right and represent the particles (N = 1) by —— and the isoparticles (U = 1) by —— ° —— the lines of propagation of the particles in Table I will be those indicated in the last column. For the corresponding antiparticles all arrows should be reversed. An oriented line for the propagation of the charge could be added but it is unnecessary.

In Fig. 1 - column A - are given the diagrams for a number of well established fast reactions for which there is no interruption of particle or isoparticles lines.

In Fig. 1 - column B - some "slow" reactions are represented for which there is a creation or annihilation of an isoparticle line.

We should mention, finally, that if the existence of Y^- particles[5] with U = -2 (S = -3, N = 1, I = 0) should be proved[4] the present scheme could stil be used if they are represented by a particle line (N = 1) and <u>two</u> isoparticles lines:



In this case the simplicity of the original scheme would be lost. It is possible that the values U = ± 2 should be excluded for elementary particles and alowed only for compound ones.

1. M. Gell-Mann, Phys. Rev. <u>92</u>, 833, 1953; M. Gell-Mann and A. Pais, Proceedings of the Glasgow Conference on nuclear and meson Physics, 324, 1954.

2. T. D. Lee and C.N. Yang, Phys. Rev. <u>102</u>, 290, 1956.

3. B. D'Espagnat and I. Prentki, Nuclear Phys. <u>1</u>, 33, 1956.

4. Actually there is a possibility for charged particles with U = ± 2, but for all well stablished cases (see Table I) only the values 0 ± 1, appear. The authors of reference (3) give, however, an argument against the possibility, U = ± 2.

5. Y. Eisenberg, Phys. Rev. <u>96</u>, 541, 1954; M. Goldhaber, Phys. Rev. <u>101</u>, 433, 1956.

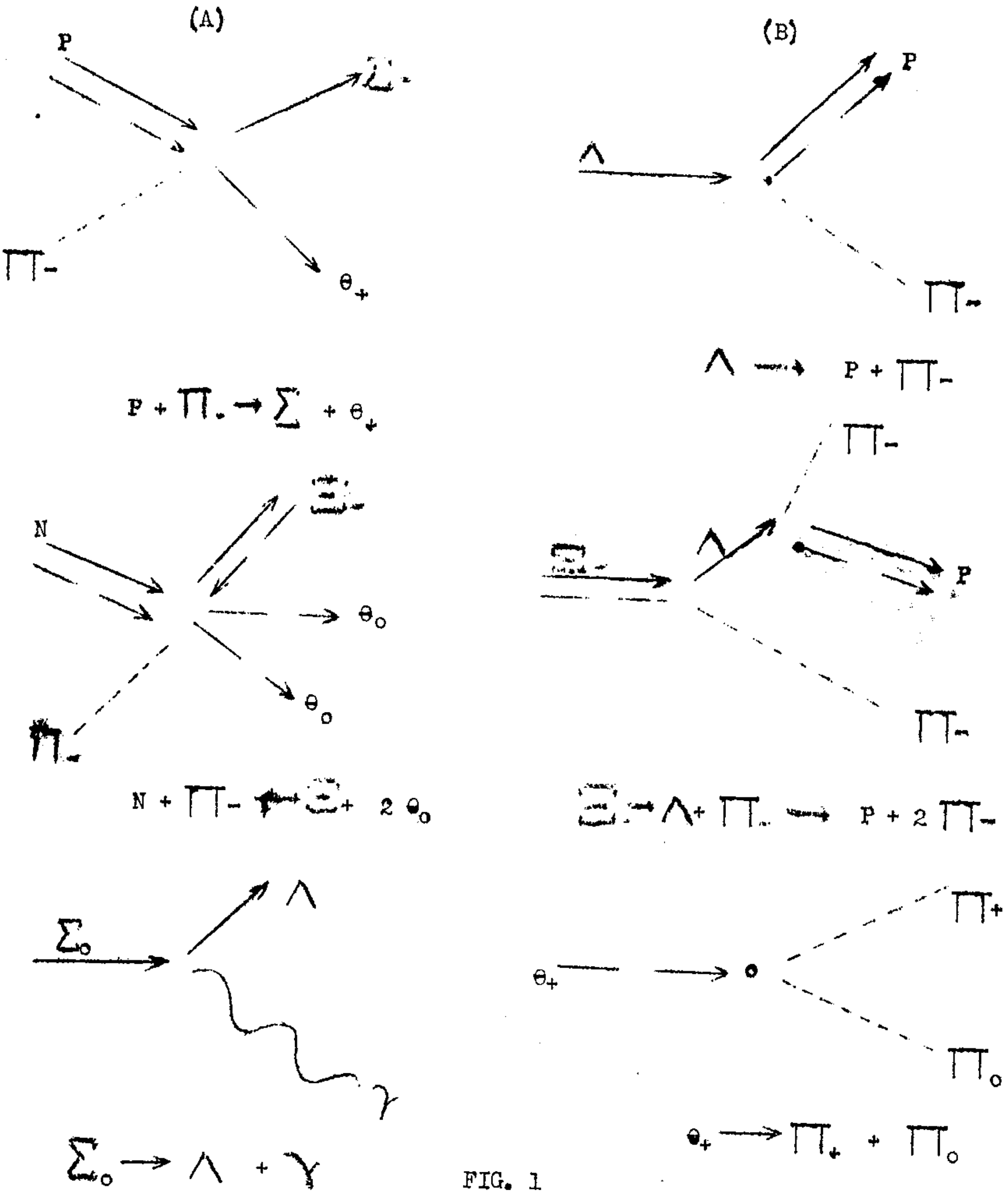


FIG. 1

Diagrams for hyperons reactions.

A - Fast reactions (conservative of U - lines)

B - Slow reactions (non conservation of U - lines)