ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
ДУБНА

E2 - 9826

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INTERPRETATION OF QUARKS HAVING FRACTIONAL QUANTUM NUMBERS AS STRUCTURAL QUASI-PARTICLES BY MEANS OF THE COMPOSITE MODEL WITH INTEGRAL QUANTUM NUMBERS

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Submitted to "Письма в ЖЭТФ"

With the unsatisfactory present-day state of the theory of strong interactions only the mathematical theory of unitary symmetry groups makes it possible to classify the multiplicity of the bound states of hadron systems observed experimentally. This theory allows one, without solving the equations of quantum-mechanical description of interactions, to distinguish in the Gilber space some invariant sub-spaces of vectors of state which correspond to certain eigen-value of an interaction Hamiltonian. Symmetries with respect to the interaction Hamiltonian are peculiar for their important property that all states corresponding to one and the same eigen-value of the Hamiltonian have similar development of the system in time. This means that all the states of the given multiplet have similar phase shifts describing interactions in the given system. Some of the miltiplets correspond to the resonance states of interaction. In this case all the states of the given multiplet refer to one and the same energy level. The classification of bound hadron states according to their masses and quantum numbers of invariant operators is complicated only by the violation of unitary symmetry. With a safe and definite affiliation of experimentally obtained resonances to the given multiplet of the known dimensions it becomes possible to predict new particles and resonances. The experimental discovery of the predicted exotic hyperon with a strangeness $S=-3$ has proved to be a triumph of the group approach.

The possibility of obtaining all the multiplets of $D^m(J^P)$ of the group symmetry by a simple multiplication of some initial multiplets, the so-called fundamental multiplet D_0^k, of the given group is a remarkable property of group symmetry. The hypothesis implying that with some sufficient combination of symmetry groups the multiplication of fundamental multiplets of the expanded group shows the physical structure of hadrons.

At present a unitary group of SU(3) symmetry is considered to be a sufficient symmetry group. The successful filling in of its multiplets $J = 0^-, 1^-, 1/2^+$ and $3/2^+$ by meson and barion resonances made important the problem of obtaining these multiplets by means of the fundamental triplets of the SU(3) symmetry. This problem requires the interrelated solution on the choice of initial triplets and the interpretation of filled in multiplets by the products of initial ones.

It is not difficult to interprete the meson nonets $D^9(0)$ and $D^9(1)$. They are the fundamental triplets D_0^3 multiplied by the fundamental anti-triplets $\tilde{D}_0^3$. Certain difficulties appeared when interpreting a barion octet and a decouplet. Gell-Mann and Zweig /1/ have solved this problem by proposing the triplets of magic quarks u, d, s and anti-quarks $\tilde{u}$, $\tilde{d}$, $\tilde{s}$ with fractional electric charges as the fundamental ones. Barion multiplets were interpreted as the products of three quark triplets and, respectively, the quarks were attributed the barion number 1/3. This composite model gave a ratio of −2/3 for the magnetic moments of the neutron and proton which agrees well with experiment. Now it is considered the most substantiated one.

Despite the absolute success of this composite hadron model and the obvious fact of obtaining all the known resonance states of multiplets by multiplying the chosen triplet representations of quarks their affiliation to the fundamental triplet, in general, and to the eigen-values of the system of multiplets of the SU(3) symmetry can be called in question. The coordinate space of the whole totality of states of the given symmetry both common for the whole multiplet and different for each state inside the multiplet is given by the eigen quantum numbers of all the operators of the given group. Among the eigen-states of the SU(3) symmetry there are no quantum numbers with the values of 1/3 for the barion number, as well as

+2/3 and −1/3 for the electric charge. Thus, the earlier proposed triplet of quarks is not fundamental from the point of view of the group approach and consequently this hypothesis on barion structure is not confirmed by that of the multiplets of the SU(3) symmetry. This hypothesis is only a successful distribution of the known resonant states into some structural parts. There are no reasons, on the whole, to consider a physical state with a barion number of 1/3 to be possible. Just this number, by definition, describes the affiliation of the barion family and it can have only the values of +1 , 0 and −1 for elementary particles. Therefore, to search for quarks both in free states and to interprete them as real dynamic systems held in potential hadron "bags" seem unjustifiable.

The idea of identifying quarks with quasi-particles has been discussed several times. However, from this conception it appears necessary to search for quark interpretation by establishing the barion structure corresponding to the mathematical procedure of obtaining multiplets from fundamental triplets. The SU(3) group corresponds to the expansion of the isospin group due to addition of the quantum strangeness number. The fundamental triplet should apparently consist of isodoublet states with $S=0$ and the isosinglet with $S=-1$ with the remaining quantum numbers corresponding to the eigen states of group-generators. Such a triplet can be composed of three fundamental fermions p^* , n^* , λ^* with $B=1$ and $Q=+1, 0, 0$. The fact that being multiplied by itself this triplet D_0^3 cannot give barion multiplets, evidences for a more complex barion structure including the states of anti-particles $\tilde{p}^*$, $\tilde{n}^*$, $\tilde{\lambda}^*$. The structure $D_0^3 \times D_0^3 \times \tilde{D}_0^3$ results in limited barion multiplets for earlier discussed models [2]. Therefore, the simplest barion structure is $D_0^3 \times D_0^3 \times D_0^3 \times \tilde{D}_0^3 \times \tilde{D}_0^3$. The product including only $\tilde{p}^* \times \tilde{n}^*$ contains all the known barion multiplets of the quark model. The remaining products with $\tilde{p}^* \times \tilde{\lambda}^*$ and $\tilde{n}^* \times \tilde{\lambda}^*$ may not correspond to the bound states of the five-fermion system.

This new barion structure allows an obvious interpretation of fractional quantum numbers in the conventional three-quark model and the new quantum number in the colour of the Bogolubov-Nambu model * . This structure does not require a necessary introduction of new gluons. It does not exclude the closed "bootstrap" version when the fermions of the fundamental triplete coincide with the appropriate states of the barion octete $D^{8}(1/2^{+})$.

In conclusion the author considers it his pleasant duty to thank Prof. D.I.Blokhintsev whose discussions have stimulated the search for a new composite hadron model.

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Received by Publishing Department
on May 28, 1976.

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* The transition of fundamental particles with $B=1$, $s=1/2$ to states of strongly bound antiparticles with $B=0$, $s=0, 1$ should take place in such a system. The effective values for each sub-system are $B=1/3$, $s=1/2$, $Q=2/3$ or $-1/3$. The coordinate variations of three spin-states simulate conservation according to three colours of quarks.