Strong Interactions in the Landscape of 60-ies

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This a kind of extended introduction to the talks of Prof. Y. Ne'eman and Prof. B. Maglich given at the special session of the Workshop devoted to 40th anniversary of theoretical discovery of unitary symmetry and experimental discovery of ω-meson.

Decennary 1961–1969 will remain in history of physics as the time of "Sturm und Drang" on the frontier of human knowledge of strong interactions.

Two, now so famous, theorists, Yuval Ne'eman and Murray Gell-Mann made almost simultaneously a seminal breakthrough and found a surprisingly beautiful order in the world of strongly interacting particles, later named hadrons. Further details of this "belle èpoque" of particle physics are presented in the splendid contribution by Prof. Ne'eman. Experimental evidences in favour of unitary symmetry were found almost immediately. The most striking were brilliant discoveries of ω-meson (1961, B. Maglich) or of Ω-hyperon.

Here I take the opportunity to briefly trace the development of ideas in the strong interaction physics during the 60-ies of the last century from a special standpoint of two ways: aristocratic and democratic. These ways were identified by G. Chew, the most fervent proponent of the "nuclear democracy".

To be exact, one calls aristocratic a way of thinking according to which the exploration of the structure of matter is a consequent penetration to new structure levels, characterized by their proper space-time or mass scales. Within every structure level one finds some fundamental or truly elementary units which constitute the basis for constructing of all variety of objects. This paradigm which stems from Democritos is often assimilated to Russian matryoshka.

For example in the initial period of the use of unitary symmetry some hadrons were considered as fundamental units. Very soon it was realized that this rôle should be given to the fundamental triplet of quarks (1964, Ne'eman, Gell-Mann, G. Zweig, R. Serber, H. Goldberg), furnished later with "colour" (1965, Bogolubov–Struminsky–Tavkhelidze, Han-Nambu, Miyamoto), whose gauging led to QCD of our days.

In the end of 1960-ies (1968-69) it was suggested that some high-energy observations ("scaling") were nicely explained by quasi-free pointlike constituents, partons (M. Markov, J.D. Bjorken, R.P. Feynmann). Further identification of partons with quarks seemed to solidify the aristocratic paradigm in particle physics.

However, in parallel with that the democratic or "bootstrap" approach was advocated and elaborated by G. Chew and S. Frautchi (1961) who took use of T. Regge's discovery (1959) of moving poles in the plane of complex angular momentum in quantum mechanics and generalized the concept to the whole realm of relativistic particle physics. The idea caused a flood of papers and further developments.

According to the "bootstrap" ideology none of the hadrons can be considered as more fundamental than any other (including even nuclei!). All infinitely many hadrons "constitute" any given hadron. The main principle is now not the finding of basic units but the search for a unique solution of some (infinite) set of consistency equations. No Lagrangian, no fields, only observable S-matrix elements. Very popular and successful in the beginning, this extremely positivistic program (which

actually was pushed forward much earlier by W. Heisenberg (1943)) some very interesting and suggestive results, e.g. finite-energy sum rules (1967, Logunov–Soloviev–Tavkhelidze) and "duality" (1967, Dolen–Horn–Schmidt), seemed to lose its initial impetus. But by the end of 60-ies a model amplitude explicitly displaying duality and crossing was discovered (1968, Veneziano, Suzuki). Per se it did not give too much for understanding of the real hadronic dynamics. However a year later this model of strong interactions was interpreted by Nambu and Susskind as the model of "string interactions". Thus the democratic way led paradoxically to something which looked a bit aristocratic, i.e. some new (non-local) fundamental entities, strings. At present, as we know, this trend is degenerated into what people call "Theory of Everything".

Does it mean that the democratic paradigm failed? First of all we have to note that in some sense Chew turned out right: none of the really observed strongly interacing particles can be considered as fundamental. In any collisions or decays of hadrons one sees only hadrons: the quarks are confined, unobservable. So the hadrons "consist" of quarks in some very specific way, sharply different from standard compositeness when after a strong enough hit one can detect constituents. Moreover, from the point of view of the string theory the quarks are not fundamental objects but are just the lowest excitations of presumably infinitely many states of the string, which is characterized by the essential attribute of the "nuclear democracy", Regge trajectories.

To end up I have to confess that on the one hand reality seems to me much more interesting and surprising than something which can be cast into one or another ontological scheme. On the other hand we can not move further without concepts and paradigms. Such is our, inherent to human mind, way to express our thoughts and to put frameworks for research. From this point of view recent developments can be considered as a dialectic merger of aristocratic and democratic ways.

Coming closer to our subject we have to be aware that further progress were impossible without great discoveries of 60-ies, which demonstrated all the power and euristic value of the symmetry principles which permeating both ways, democratic and aristocratic, and capable to lead to new paradigms both underlying and surpassing the previous ones.