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APR 21 1980

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8-FLAVORED QUARKS

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March 1980

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TOPOLOGICAL BOOTSTRAP PREDICTION OF 3-COLORED 8-FLAVORED QUARKS

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ABSTRACT

We describe a topological bootstrap theory of strong interactions that generates baryon number, 3 colors and spin- $\frac{1}{2}$ confined "quarks" with 8 flavors. Extension to electromagnetism allows the topological objects called "quarks" to be associated with leptons, so 8 leptons are predicted.

An apparently complete topological S-matrix bootstrap theory of hadrons is described in detail in Ref. (1). This letter summarizes certain quantum number and symmetry predictions of the theory, which is based on unitarity and causality in conjunction with an S-matrix (combination) topological expansion. We do not here discuss "dynamical" (e.g., mass spectrum) predictions, which have not yet been worked out although methods described in Ref. (2) are appropriate.

Each topological expansion component is associated with a pair of 2-dimensional surfaces together with certain graphs embedded on the surfaces. One of the surfaces is bounded and embeds both Landau graphs⁽³⁾, which carry energy-momentum, and Harari-Rosner (HR) graphs⁽⁴⁾, which carry spin; this "classical" surface thus describes direct physical observables. A second, closed surface is transverse to the classical surface and provides the boundary thereof by its intersection. This closed "quantum" surface is covered by triangulated discs, each disc being associated with an "elementary" hadron; the orientations of the quantum-surface triangulation pattern carry "internal" (not directly-observable) quantum numbers.

Each surface pair has a well-defined complexity, with the "entropy" property that complexity cannot decrease and usually increases under those connected sums that express S-matrix unitarity. The only self-generating complexity level is that of "zero-entropy"--classical planes bounded by quantum spheres, with the entire classical plane having a single orientation and containing a single Landau vertex. The nonlinear bootstrap problem is thus concentrated at the zero-entropy level; particle symmetries

and quantum numbers originate in zero-entropy self consistency. More complex surface pairs, whose symmetries diminish with increasing complexity, are all generated by connected sums of zero-entropy surface pairs.

Unitarity and causality at zero entropy have led us to a definite triangulation pattern for the quantum sphere, with an associated classical-plane intersection belt, and a definite pattern of HR and Landau graphs on the classical surface. The baryon number, flavor and spin aspects of the experimentally-observed hadron spectrum are explained by this bootstrap pattern, an important aspect of which can be associated with spin- $\frac{1}{2}$ "quarks" carrying 8 possible flavors. (Momentum is carried not by quarks but by Landau arcs.) The relation between baryon number and quark number corresponds to 3 "colors". Baryoniums as well as mesons and baryons are predicted but no further "elementary" hadrons.

Figure 1(a) shows the structure of typical meson, baryon and baryonium⁽⁵⁾ discs, and Fig. 1(b) gives an example of a quantum sphere covered by 4 elementary-hadron discs. The dashed curve is the belt--the intersection with the classical surface--and Fig. 1(c) shows the corresponding classical surface with the embedded Landau (dashed) and HR(solid) arcs. The HR arc orientations reflect the orientations of those triangles on the quantum surface that are cut by the belt.

Within a particle disc there may be core triangles, always cut by the classical belt, that contribute no edges to the particle-disc perimeter. The number of counterclockwise minus clockwise core

triangles is conserved and identifiable with baryon number B . Each peripheral triangle, contributing two oriented edges to a particle-disc perimeter, is identifiable as a "quantum quark". The number of clockwise minus counterclockwise peripheral triangles may be defined as quark number q . For strong-interaction surfaces $q = 3B$, and one may associate one of 3 different "colors" with a quantum quark attached to a core triangle because each edge of the latter is topologically distinguishable from the other two edges. If the quantum-surface building unit were a polygon with N sides then $q = NB$, but for $N \neq 3$ the quantum-classical relationship is inconsistent, as we now explain.

Not all peripheral triangles can be cut by the classical belt if $N > 2$ (see Fig.1b), and spin-carrying classical quark--HR arcs on the classical surface (see Fig.1c)--correspond only to belt-intersect quantum triangles. For $N = 3$ there is a one-to-one correspondence between peripheral triangles uncut by the belt and core triangles (which are always cut); thus there is one to one correspondence between quantum quarks and classical quarks (compare Figs.1b and 1c). Such cannot be the case for $N > 3$, and for $N = 2$ (no core triangles) the triangulation pattern loses the feature that particle discs are unambiguously delineated by trivial vertices (one cannot tell where a particle disc begins and ends). Thus $N = 3$ is unique.

Flavors correspond to the orientations of the 3 edges building a quantum-quark perimeter. The 8 possibilities are shown in Fig. 2. Each flavor is separately conserved. When electromagnetism is introduced we associate electric charge with the orientation of that special edge cut by the classical belt because any direct

observable should make contact with the classical surface. Thus our flavors are grouped into 4 charge doublets.

The two possible orientations of the classical belt cutting a quantum quark correspond to the two orientations of spin $\frac{1}{2}$; quarks are either right handed or left handed. Parity (P) is conserved because left-handed and right-handed configurations always appear in matched component pairs within the topological expansion, a circumstance stemming from the orientability of quantum surfaces and classical belts. This orientability also ensures charge-conjugation (C) invariance and T invariance.

Topological quarks carry spin and flavor but not momentum and, because of zero-entropy contraction rules for triangles on a quantum sphere, single-triangle discs cannot be associated with particles. Introduction of electromagnetism changes the situation because electromagnetic currents correspond to quantum surfaces that need not satisfy zero-entropy contraction rules. A single triangle adjacent to triangles of opposite "handedness", a configuration never occurring on any strong-interaction quantum surface, now may be associated with a physical particle. The natural interpretation is a lepton; we therefore predict 4 charge doublets of leptons, corresponding to Fig. 2.

What is the connection between QCD, which tolerates any number of colors and flavors, and topological bootstrap theory? We base a speculative answer on the following facts: (1) Low-complexity components of the topological expansion are dominant only at small $p_L^{(2)}$. (2) Classical physics becomes relevant for highly complex systems. (3) Quantum field theory has so far achieved meaning only as a perturbative correction to a classical limit.

(4) For QCD the latter requires high p_L . We are led to speculate that local space-time, secure only as a classical concept, acquires asymptotic meaning in a high complexity limit but is not defined in the opposite limit of zero complexity. Quantum field theory correspondingly, we conjecture to be meaningful only for high complexity, which for strong interactions means high p_L . If, as we have asserted, the triangular nature of the quark is a consequence of zero-complexity self consistency, triality cannot be deduced in a local field theory. In the description of particle phenomena, local field theory and combinatorial topology respectively appear appropriate to opposite complexity limits.

A plausible way to describe weak interactions within the general topological approach is via nonorientable quantum surfaces and (or) nonorientable classical belts. We are studying this possibility and have found indications that the arbitrary features of "standard" weak interaction theory can be understood. Nonstandard predictions for certain components of the weak current are likely.

We are indebted to many colleagues for advice and discussion. Particularly influential have been J. Finkelstein, H. P. Stapp, J. P. Sursock, G. Veneziano, and G. Weissmann.

This work was supported by the High Energy Physics Division of the U.S. Department of Energy under contract No. W-7405-ENG-48.

FOOTNOTES AND REFERENCES

1. G. F. Chew and V. Poénaru, "Topological Bootstrap Theory", LBL-9768, Feb. 1980, submitted to Nuclear Physics B. An earlier proposal (G. F. Chew, Nucl. Phys. B. 151, (1979), 237) made before recognition of the simultaneous need for both classical and quantum surfaces, has been found defective.
2. G. F. Chew and C. Rosenzweig, Phys. Reports 41C, #5 May 1978.
3. D. Iagolnitzer, The S Matrix, North Holland, Amsterdam 1978.
4. H. Harari, Phys. Rev. Letters 22, 562 (1969); J. Rosner, Phys. Letters 22, 689 (1969).
5. Contraction of a baryonium disc to a meson disc of the same flavor content and same total spin is blocked at zero entropy by a mismatch of left-handed and right-handed quarks (see below).

FIGURE CAPTIONS

1. (a) Typical elementary hadron discs.
 (b) A quantum sphere covered by a meson disc, a baryonium disc and two baryon (or baryon-antibaryon) discs. As drawn, the back side of the sphere is covered by one of the baryon core triangles. Note the consistent alternation of triangular patch orientations and the fact that each triangle has a unique "mate" of matched orientations with which it shares three vertices. Note also the two special vertices ("north and south poles") shared by all particle discs and by all core triangles.
 (c) The classical plane (hemisphere) whose boundary is the dashed belt ("equator") in Fig. 1(b).
2. The eight possible sets of edge orientations for a clockwise-oriented peripheral triangle intersected by the classical belt. Depending on the surface pair, such triangle may represent quantum quarks or leptons.

Figure 1

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Figure 2