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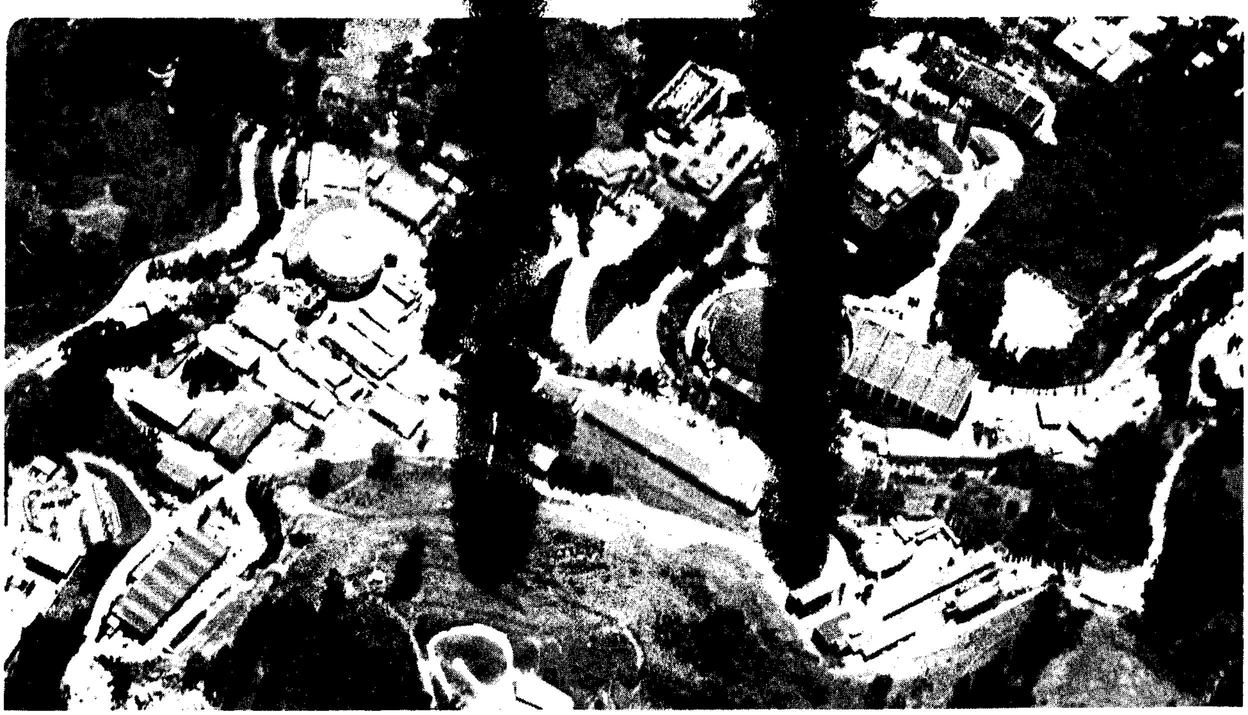

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TOPOLOGICAL "VECTOR GLUONS"*

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ABSTRACT

A topological representation for individual quark chirality is proposed which eliminates spin lines from the classical surface and provides "chiral entropy" through patch-boundary lines that correspond to chirality reversal. The effect on quark spin makes it appropriate to describe such a patch-boundary line as a "topological vector gluon". The chiral entropy index is equal to the number of "vector gluons".

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I. INTRODUCTION

It has been discovered by Mandelstam[1] and Stapp[2] that at the lowest level of the topological expansion--a level now called "zero-entropy"--quark spin propagators are similar to Harari-Rosner (HR) Kronecker-delta flavor propagators if spin dependence is expressed through the dotted and undotted indices that characterize (0, 1/2) and (1/2, 0) representations of the Lorentz group. The degree of freedom here is closely related to chirality: at zero entropy one may speak of "chiral quark doubling", a quark of given flavor and spin appearing in two forms--called "ortho" and "para" in Refs. (2) and (3). Dirac's 4-component spinors provide a natural representation of the ortho-para distinction which, like "topological color",[3,4] is an inaccessible degree of freedom that automatically becomes erased by the topological expansion building a physical amplitude from topological amplitudes. Ortho-para quark doubling is essential in determining the value of hadron coupling constants through $SU(6)_W$ rules and their super-symmetric extension--[1,5] rules persuasively supported by experiment.

Topological particle theory associates each particle property with some embellishment of a "quantum-classical" intersecting pair of surfaces.[3] Consistency requirements--from the entropy notion central to the theory--constrain the embellishments but, because these demands are not yet fully understood, a process of trial and error has been occurring. Several classical-surface proposals have by now been made with respect to the chiral degree of freedom.

We here describe a classical-surface embellishment that seems to us at once more economical and more consistent than its predecessors, from which it nevertheless borrows certain features.

Attractive aspects of the chirality represention here to be described include: (a) Spin arcs on the classical surface are eliminated; spin effectively flows alongs the surface boundary ("belt"). (b) An essential role is played by the "momentum-copy" arcs introduced by Ref. (4) for a different purpose--the description of "quark-color" switching. (c) New lines appear automatically in ortho-para transitions--lines that can appropriately be called "topological vector gluons". (d) "Vector-gluon" ends lie along the momentum graph and prevent contraction of the adjoining graph vertices; the number of vector gluons is correspondingly an entropy index.

II. ORTHO-PARA PATCHES ON THE CLASSICAL SURFACE

It was proposed in Ref. (3) to patchwise orient the classical surface, a patch being designated as ortho if the patch orientation agrees with a global (HR) orientation induced by the quantum surface and para otherwise; Mandelstam-Stapp chiral quark doubling was associated with ortho-para patching. We shall also introduce oriented patches and associate local orientation with the chiral degree of freedom. Our patch boundaries, however, are different from those of Ref. (3) and we shall require certain patches not to be oriented.

The proposed patches are bounded by momentum arcs together with the belt, as illustrated by the 4-meson (A, B, C, D) examples of Fig. 1. Notice that a momentum arc is part of a patch boundary only if its two adjoining areas have opposite orientation. Each of the 4 areas in Fig. 1 can be oriented independently of the others. Our use of the momentum graph to divide the classical surface into areas ensures that each trivial belt vertex--where one particle boundary piece meets another particle boundary piece--attaches to exactly one oriented area*, and vice versa. Now, topological quarks associate with those belt pieces adjacent to trivial belt vertices, with mated belt pieces adjacent to the same trivial vertex representing "in" and "out" aspects of the same quark. Thus the belt portion of the boundary of each zero-entropy oriented area belongs to a distinct quark and, conversely, every zero-entropy quark attaches to an oriented area* if we treat the color #2, 3 momentum-copy arcs of Ref. 4 on the same basis as #1 momentum arcs.

* The zero-entropy oriented area belonging to a quark constitutes a "patch" only if adjacent quark areas have opposite orientation.

Areas of the classical surface adjacent to junction lines are not oriented.* Such an area has no trivial belt vertex and no corresponding quark. Figure 2 presents the example of the #1-colored sheet associated with a 2-baryon (A, C), meson (D), baryonium (B) zero-entropy amplitude. There are 4 additional sheets here, two colored #2 and two colored #3, each sheet with one trivial belt vertex. One of these "secondary" sheets is shown in Fig. 3. The total number of quarks in this example is 6, each attached to an independently-oriented classical-surface area. The familiar quark-line diagram for the process of Fig. 2 is shown in Fig. 4, with (redundant) color labels added. The ortho-para degree of freedom belonging to each quark line is not naturally exhibited through Fig. 4, but can be regarded as an added 2-valued index for each line.

* Such an area attaches to quantum-surface[3] "core triangles" which carry no spin.

III. "VECTOR-GLUON" LINES

What happens to the topology when an ortho "out" quark is plugged to a para "in" quark, or vice versa? The connected sum of classical surfaces develops an internal segment of patch boundary which does not coincide with a momentum arc but which has one end on the momentum arc attached to these quarks. The new patch-boundary segment is the remnant of the identified belt pieces belonging to the "in-out" plugged quarks. These matched belt pieces are erased in an ortho→ortho or para→para plug but remain as part of a patch boundary in an ortho→para plug. A single-meson plug example is given in Fig. 5a, where one quark mismatch occurs. Figure 5b shows a 2-meson plug where there are 2 quark mismatches.

We shall refer to the new patch boundary lines as "topological vector gluons". For each quark mismatch there is generated one end of a "vector gluon" line that touches a momentum arc. A "vector-gluon" vertex along a momentum line blocks contraction of the adjacent vertices of the momentum graph. The total number of such "vector-gluon" vertices (points of "emission" of "vector gluons") is an entropy index as defined in Ref. (3). This "chiral" index has the value 1 in Fig. 5(a), the value 2 in Fig. 5(b), and the value 4 in Fig. 5(c).

Every "vector-gluon" line has one end on a momentum arc. The other end may be at a trivial belt vertex (Fig. 5a) or at a point internal to a closed loop where it meets an odd number of other "vector gluons" (Figs. 5 b,c).

If a quark ortho-para transition occurs in a plug simultaneously with a color switch, then the topological vector-gluon line may be regarded as lying along a color patch boundary,[4] with the gluon carrying a corresponding pair of color indices. Such a notion adds nothing to the content of our scheme but may help in making contact with QCD ideas.

Why do we use the adjective "vector" in connection with patch boundaries generated by ortho→para quark transitions? The justification for such language may be found in Appendix B of Ref. (6) where it is shown that the quark spin structure of such transitions is that of a right-handed or left-handed vector current, coupled to a vector parallel to the momentum of the plugged particle. Topological gluons do not carry momentum, but topological "vector gluons" in effect carry spin. In a parallel paper we discuss the modified representation of electromagnetic topologies that accompanies the introduction of ortho-para zero-entropy patches bounded by momentum arcs. The vector character of the photon is represented by a "photon spin line" that constitutes an ortho-para patch boundary segment in exactly the same sense as a "vector-gluon" line. The photon, of course, also has a momentum line and occupies a segment of the belt; the photon is a particle. A topological vector gluon is <u>not</u> a particle even though it carries spin and "color".

IV. DISCUSSION

A feature of the Ref. (3) proposal associating independent quark chirality with the order of charge and spin arcs was the absence of a topological reason preventing a spin-charge crossing--corresponding to an ortho-para transition (called "quark twist" in Ref. (3)) from being slid past a momentum-graph vertex and annihilating another such crossing. The topology, that is to say, did not naturally provide a chiral entropy. Another feature of the Ref. (3) proposal was the redundancy between spin lines and belt. The present proposal eliminates spin lines and at the same time achieves a satisfactory chiral entropy. A further attractive feature is the automatic appearance at nonzero entropy of new lines with certain properties of orthodox gluons. (No feature resembling a gluon appears elsewhere in topological theory.)

A puzzling aspect of our proposal is the presence of <u>nonoriented</u> classical-surface areas adjacent to junction lines. Alternatively we might assign to these areas a <u>fixed</u> orientation, but then we would lose the association proposed in Ref. (3) between the parity transformation and reversal of classical-surface orientation. This association with parity is maintained by the proposal described here.

Also maintained are the supersymmetric elementary hadron coupling-constant <u>ratios</u> described in Ref. (5) together with the zero-entropy equations described in Ref. (7) which determine the value of the zero-entropy coupling constant g_0. We have lost, however, one overall factor of 2 employed in Ref. (5) in the relation between g_0 and physical coupling constants. This factor would be maintained if the global orientation of the classical surface were independent of the quantum-surface orientation, but we have so far been unable to find a consistent place for independent quantum-classical global orientations.

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FIGURE CAPTIONS

1. Examples of zero-entropy classical surfaces for a 4-meson event.
2. Examples of zero-entropy classical sheets colored #1 for a 2-baryon, meson, baryonium event.
3. Examples of classical sheets colored #2,3 for the same event as in Fig. 2.
4. Quark-line diagram corresponding to the classical surfaces of Figs. 2 and 3.
5. Examples of connected sums that lead to one or more topological vector gluons. (a) 1 gluon (b) 2 gluons meeting in the interior of a closed loop. (c) 4 closed-loop gluons.

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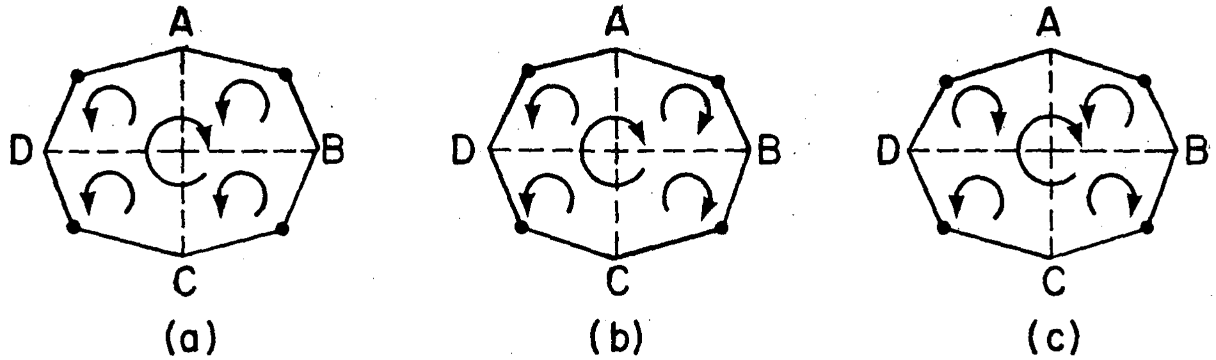

FIGURE 1

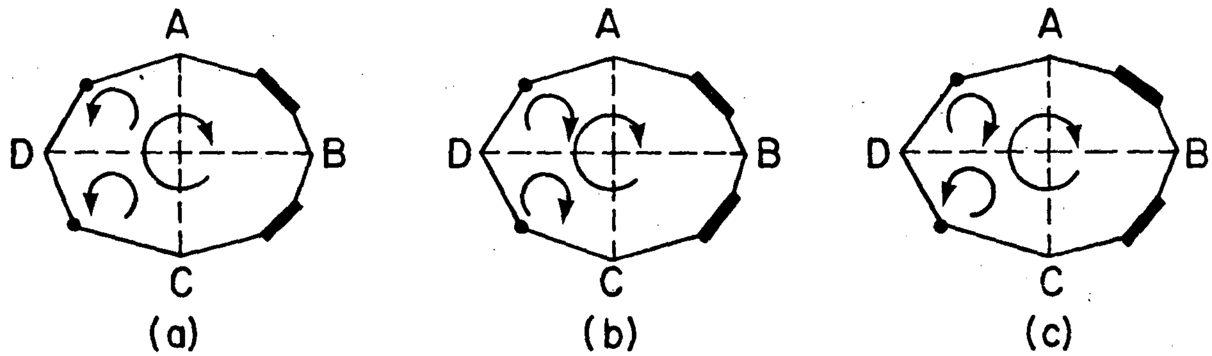

FIGURE 2

junction line
belt
momentum arc
trivial vertex

FIGURE 3

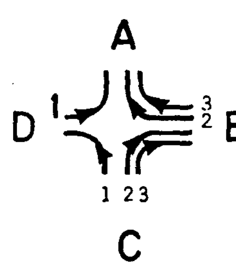

FIGURE 4

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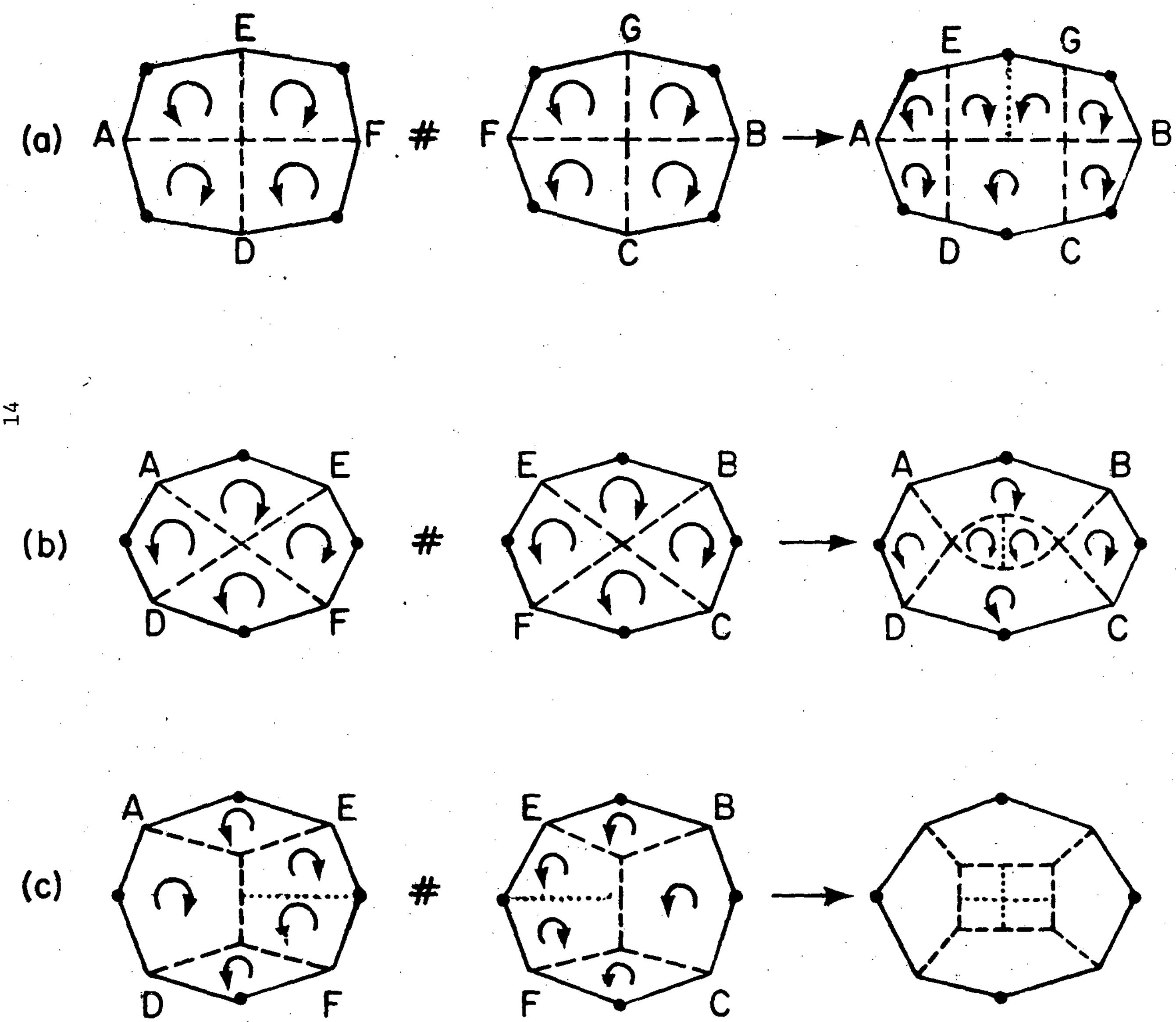

FIGURE 5

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