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TOPOLOGICAL THEORY OF ELECTROWEAK VECTOR BOSONS*

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Extension of topological particle theory to weak interactions may be expected to require topological representation of a charge-carrying family of electroweak vector bosons that enlarges the representation developed for the photon.[1] This note describes an immediate generalization that predicts a quartet of vector bosons--associable with the γ, Z_0, $W^{\pm}$ of Weinberg-Salam theory.[2]

Recall that the quantum-surface (Σ_Q) component corresponding to a photon is an oriented sphere covered by two oppositely-oriented triangular disks.[1] Let us generally characterize by + (-) a quantum triangle whose orientation agrees (disagrees) with the (global) orientation of the Σ_Q component on which it resides.[3] The complete Σ_Q (generally a collection of closed components) is covered by triangular disks of alternating orientation; that is, Σ_Q is patchwise oriented. Each triangle intersects a piece of the classical-surface (Σ_C) boundary, and ending on the interior of this boundary piece is exactly one charge arc--which lives in Σ_C. The other end of this charge arc lies inside some other quantum triangle, so each triangle is coupled by an oriented charge arc to exactly one other triangle. A (+) quantum triangle attached to a charge arc directed "out of" Σ_C carries (outgoing) electric charge +1 while a (-) quantum triangle attached to a charge arc directed "into" Σ_C has (outgoing) electric charge -1. For the other two possibilities the electric charge of the triangle is 0. The two triangular disks comprising a photon carry, respectively, electric charge +1 and -1.

Each quantum triangle is "mated" in a well-defined sense[4] to exactly one other triangle of opposite orientation lying on the same component of Σ_Q. Electromagnetic interactions are characterized by a rule that "active" charge arcs--connecting nonmated quantum triangles--have both ends on charged triangles. This rule allows a coherent (HR) global orientation of Σ_C and facilitates separate C,P,T symmetries. (Strong interactions have no active charge arcs.) It is natural to introduce weak interactions by allowing active charge arcs with one or both ends on a neutral quantum triangle. Charge can be seen to be conserved by considering the active charge arcs in pairs--the two members of an arc pair ending on the 4 quantum triangles that constitute 2 mated triangle pairs. There are then four 2-triangle combinations that can correspond to a vector boson, as shown in Table I.

Table I

Quantum triangle	orientation →	(+)	(-)	
	charge ↓	+1	-1	γ
		0	0	Z_0
		+1	0	W^+
		0	-1	W^-

We do not associate flavor-edge orientations with any of the electroweak vector-boson quantum triangles nor do we attach spin (HR) arcs thereto. The only embellishment is electric charge. As for a photon the spin and parity of any electroweak vector boson is represented through the patchwise orientation of Σ_C.[1] The quantum

numbers of topological electroweak vector bosons then precisely match those of Weinberg-Salam.[2] Topological plugging rules[4] do not allow a neutral triangle to be plugged to a charged triangle, so we must identify (-1, +1) and (0, 0) with separate physical particles even though both these combinations carry zero total charge.

It is natural to postulate that minimal electroweak topology has the same structure as minimal electromagnetism--where two charge arcs from a photon sphere pass to the two members of a mated charged-triangle pair on a different sphere covered either by leptons, or by hadrons. One now simply allows an active charge arc to be oriented independently of the orientation of the two quantum triangles on which it ends, so that neutral triangles may be involved. Requiring more thought is the generalization of the coupling-constant rules that were needed to achieve gauge invariance for topological electromagnetism.[1] We expect that maintenance of unitarity in higher topologies will require universal electroweak coupling-constant rules that for leptons agree with Weinberg-Salam theory, where it is known that many aspects of the rules are deducible from unitarity.[5] We hope that the arbitrary aspects of Weinberg-Salam coupling-constant rules will not remain arbitrary in topological theory but we make no such claim at present. Our coupling rules for hadrons will necessarily differ somewhat from those of standard theory because of the core triangles in topological theory and the integral electric charges of quarks. At low q^2, however, the $W^{\pm}$ coupling to hadrons is controlled by total hadronic charge and correspondingly has the "standard" form. We shall consider elsewhere the low-q^2 prediction of topological theory for Z^0 coupling to hadrons.

A final remark concerns the minimal coupling to each other of 3 electroweak vector bosons. The topology here associates one of the vector bosons with a closed sphere but each of the other two is a disk; the two disks collectively cover a different sphere. Our remark is that whenever a photon is involved it is natural to require that the photon should always reside alone on a sphere. The photon is then the only elementary particle in topological theory that never appears as a quantum disk (with boundary) but always as a closed component of Σ_Q. We anticipate an eventual connection of this unique topological feature with the photon's zero mass. Such a connection would mean that (physical) neutrinos[6] have nonzero mass.

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2. S. Weinberg, Phys. Rev. Lett. 19, 1264 (1967); A. Salam, Proc. 8th Nobel Symposium, Stockholm, ed. N. Swartholm (1968).
3. In Ref. (1) the + (-) degree of freedom was characterized as "clockwise" ("anticlockwise").
4. G. F. Chew and V. Poénaru, Phys. Rev. Lett. 45, 229 (1980); Lawrence Berkeley Lab. preprint LBL-11433, submitted to Nuclear Physics B.
5. See, for example, J. C. Taylor, Gauge Theories of Weak Interactions Cambridge Univ. Press, Cambridge [1976].
6. In Ref. (1) a charged lepton is associated with a charged (triangular) quantum disk that carries flavor-edge orientations as well as the ends of a spin (HR) arc and a momentum (Landau) arc. A topological neutrino has the same structure except that the quantum triangle is electrically neutral.