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Publication Date

1983

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Physics, Computer Science &
Mathematics Division

Submitted for publication

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January 1983

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January 1983

LBL-15661

Electrospin and Broken SU(2) Symmetry***G. F. Chew*****Lawrence Berkeley Laboratory******and******Department of Physics******University of California******Berkeley, California 94720******and*****J. Finkelstein†*****Department of Physics******San Jose State University******San Jose, California 95192*****Abstract**

We identify within topological particle theory a broken SU(2) "electrospin" symmetry and enumerate a related collection of exact and approximate conservation laws. One component of electrospin, equal to $Q - 1/2 (B-L)$, is always conserved. The connection of electrospin with strong and weak isospin is discussed.

*This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U.S. Department of Energy under Contract DE-AC03-76SF00098.

†Participating guest at Lawrence Berkeley Laboratory.

In this paper we discuss $SU(2)$ symmetry within topological particle theory.⁽¹⁾ We identify within this theory a broken $SU(2)$ symmetry, which we call "electrospin", and discuss its connection with both strong and weak isospin. We will point out that one component of electrospin has value equal to $Q - 1/2 (B-L)$, and so is exactly conserved.

By generalizing Harari-Rosner dual diagrams,⁽²⁾ topological particle theory^(3,4) associates each elementary particle with a collection of ends of oriented lines: the "quark lines" of dual diagrams are here called "fermion lines", and a meson contains the ends of two fermion lines, a baryon the ends of three, and a baryonium the ends of four. There are also "junction lines" of which a baryon has one and baryonium two. An elementary electroweak boson has a pair of fermion-line ends⁽⁵⁾ (of opposite orientation, just like a meson) and an elementary lepton has a single fermion-line end together with a single junction-line end, of the same orientation.⁽⁶⁾

In this paper we must also pay attention to another kind of line: each end of a fermion or junction line is accompanied by the end of this third category of line which in the past has been called "charge arc" because of its control of particle electric-charge content.⁽⁷⁾ The present paper identifies a broken $SU(2)$ symmetry that motivates the recent Ref. (5) renaming of charge arcs as "electrospin lines".

Each electrospin line connects the head of a fermion or junction line to the tail of a fermion or junction line. In accord with Ref. (5), we characterize the orientation of an electrospin line as c ("charged") if it agrees with the orientation of the fermion or junction lines at its ends (agreement at one end ensures agreement at the other). The fermion or junction-line end then can be said to transport $+1$ unit of electric charge in the direction of the line orientation.⁽⁷⁾ If the electrospin orientation disagrees with that of the fermion or junction lines near its ends, these line ends are electrically neutral -- designated n . Any fermion-line end can be either charged (c) or neutral (n).⁽⁶⁾ Elementary particles, being "built" from the ends of fermion and junction lines, carry a quantity of electric charge which for an outgoing particle is equal to N^c , where N^c is total number of outgoing charged lines minus the total ingoing number. N^c is an absolutely-conserved quantum number that labels

physical particles as well as elementary particles.

In all strong-interaction (purely-hadronic) topologies and in topologies that represent interaction among electroweak bosons, electrospin lines with one end belonging to a fermion line invariably have the other end also fermionic, and one recognizes a $c \longleftrightarrow n$ fermion symmetry: Each fermion electrospin line may be independently reversed in orientation without affecting the amplitude. Such a discrete symmetry, which correlates two oppositely-oriented ends of fermion lines, was shown by Paton and Chan ⁽⁸⁾ to imply a continuous SU(2) symmetry in a Hilbert space where the bra vectors are direct products of $\{c_n\}$ vectors attached, each, to the head of a fermion arrow, while ket vectors similarly are built from fermion tails. The set of 3 SU(2) generators we describe as "electrospin" and denote by

$$\vec{E} = (E_1, E_2, E_3) \quad (1)$$

where E_3 is diagonal in the topological basis, with eigenvalues

$$E_3 = 1/2 (N_f^c - N_f^n), \quad (2)$$

if $N_f^{c,n}$ is the total number of outgoing (c, n) fermion lines building the particle minus the ingoing number.

Because the electrospin orientation of a junction line cannot be reversed, full SU(2) (fermionic) symmetry depends on no fermion lines having electro-connection to junction lines. But with any electro connections the quantity (2) remains conserved,⁽⁹⁾ corresponding to unbreakable symmetry with respect to rotations about the 3 axis in electrospin space.

It is possible, because fermion line ends effectively carry conserved topological quantum numbers in addition to N^c ,⁽¹⁰⁾ to break $\vec{E}$ into "quark", lepton and electroweak-boson components:

$$\vec{E} = \vec{E}^q + \vec{E}^l + \vec{E}^b \quad (3)$$

and, further, to decompose $\vec{E}^q$ and $\vec{E}^l$ according to generation G:

$$E^{q,\ell} = \sum_G E_G^{q,\ell} \quad (4)$$

For topologies where all lines (external and internal) belong to elementary hadrons, junction lines have no electroconnection to fermion lines and the electrospins $\vec{E}_G^q$ are separately conserved, corresponding to separate $SU(2)_G^q$ symmetry groups.

Such purely-hadronic topologies are further characterized by generation symmetry, which when combined with $(c \longleftrightarrow n)$ symmetry gives rise to an $SU(N_f)$ symmetry, where N_f (number of flavors) = 2x number of generations. For physical hadrons there is breaking of generation symmetry, and the topological index G need not correspond to the "physical-quark" generation index (up-down, charmed-strange, etc.). One may therefore not identify "strong isospin" with an individual $SU(2)_G^q$, although the dimensionality of the respective Hilbert spaces is the same. Whether physical and topological quark generations are connected by a "Cabibbo rotation" is presently unknown.

For topologies in which all lines belong to elementary leptons and electroweak vector bosons, each fermion line may be classified as being either left- or right-handed; and for these topologies we have separate $SU(2)_L$ and $SU(2)_R$ symmetry groups. When restricted to these particles, this $SU(2)_L$ coincides with the standard-model "weak isospin".⁽¹¹⁾

The full electros핀 $\vec{E}$ is conserved for any topology that lacks electrocoupling between junction lines and fermion lines. The third component of total electros핀 is always conserved and thereby attaches to physical as well as to elementary particles. For any particle, Formula (2) above together with Ref. (10) yields

$$E_3 = Q - 1/2 (B-L) \quad (5)$$

where Q , B and L are, respectively, electric charge, baryon number and lepton number.

Footnotes and References

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This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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