Isospin Doctoring

Thomas R. Love
Department of Mathematics
and
Department of Physics
California State University at Dominguez Hills
Carson, CA 90747
tlove@csudh.edu

8 August, 2005

Abstract

In the standard model, isospin is not defined for all elementary particles nor is it conserved in all interactions. A study of the isospin subalgebra in the author's $U(3,2)$ theory of matter shows that the standard model assigned the wrong isospin values to many elementary particles. The redefined isospin is defined for all particles and is conserved in all interactions. This leads to a new interpretation of the isospin algebra as a model of pion exchange between protons in the nucleus.

PACS: 12.60.-i Models of particles and fields beyond the standard model

1 Introduction

In his analysis of the structure of the atomic nucleus Heisenberg [7] introduced a new symmetry into physics. Since this symmetry has the same structure as the spin algebra $su(2)$, it has been called isotopic spin, isobaric spin and more recently, just isospin. Let p^+ denote a proton and n denote a neutron. The isospin algebra consists of three linear operators: τ_-, τ_+, τ_3 defined by:

$$\tau_+ : p^+ \rightarrow n$$

$$\tau_- : n \rightarrow p^+$$

$$\tau_3 = [\tau_-, \tau_+]$$

In the standard treatment, the proton is represented by the state

$$p^+ = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

and the neutron is represented by the state

$$n = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

The standard representation of the linear operators is:

$$\tau_- = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

$$\tau_+ = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$\tau_3 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

In the standard model, the Lie algebra acts on the elementary particles as states in a Hilbert space. In the model of matter introduced by the author [16, 17], the elementary particles are modeled as operators (vertical vector fields on a principle fiber bundle over a complex space-time) which form the Lie algebra and their interactions are modeled by the Lie bracket (commutator) when a change in particle type is involved or as a tensor product when there is no change in particle type. The matter matrix [17] is given by:

$$\begin{pmatrix} \gamma_1 & \nu & H & e^- \\ \bar{\nu} & \gamma_2 & n & \pi^- \\ \bar{H} & \bar{n} & \gamma_3 & p^- \\ e^+ & \pi^+ & p^+ & \gamma_4 \end{pmatrix}$$

Thus a proton is represented by the matrix:

$$p^+ = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

and the neutron is represented by the matrix:

$$n = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

The eigenvalue of γ_1 is the lepton number. We will call the eigenvalue of γ_2 the meson number. The eigenvalue of $-\gamma_3$ yields the baryon number. γ_4 represents a photon and its eigenvalue gives the electric charges of the particle. Thus:

$$\left[\gamma_4, p^+\right] = p^+$$

$$\left[\gamma_4, p^-\right] = -p^-$$

The four γ_i generate quantum numbers which define superselection rules and which partition the elementary particles into 12 superselection sectors. They also define four forces: γ_1 mediates the weak force; γ_2 is related to the spin-spin interaction; γ_3 mediates the strong force and γ_4, the electromagnetic force. For two particles, A and B, the same quantum numbers are obtained from the bracket $[A, B]$ as from the tensor product $A \otimes B$; the bracket is used when a change in particle type is involved and the tensor product is used when there is no change in particle type. The tensor force: $A \otimes B$ is an exchange force: $A \otimes B = [[A, \gamma_I], B] = [A, [\gamma_I, B]]$.

These numbers are also related to the statistics of the particle: the eigenvalue of $\frac{1}{2}(\gamma_1 - \gamma_2 + \gamma_3 - \gamma_4)$ is 0 for Bosons and ± 1 for Fermions.

Since the Lie bracket determines the interaction, this is a realization of Yang's dictum: 'symmetry dictates interaction' [26]. We might equally invert the statement and say that 'interaction dictates symmetry'. But if both statements are true, then symmetry is the interaction.

The above commutation relations, which actually work, should be contrasted with those given in the axiomatic approach to QFT, according to Haag [6]:

> The commutation relations between different fields at space-time distances are usually assumed to be: all Fermi fields anti-commute with each other, all Bose fields commute, any Bose field commutes with any Fermi field.

Thus the fundamental axioms of QFT need to be modified, all of particle physics can be done with commutators, anti-commutators are not necessary.

Heisenberg [7] introduced isospin with the idea that the proton and the neutron were two different states of the same particle, the nucleon. However, that is not true in the present model. The neutron and proton are distinct particles. Yet there is an important lesson to be learned from the isospin operators.

In the complete theory, the particles are represented by a wave function times a Lie algebra generator. Thus p^+ would be replaced by $\psi_{p^+}\partial_{p^+}$ where ψ_{p^+} is a wave function and ∂_{p^+} is a differential operator representation of the Lie algebra element. The present simpler notation is sufficient for the purposes of this paper. In the standard model, these would be a quantized Dirac four-component spinor operator. As shown in [18] the two descriptions are not inconsistent.

There is no need for anti-commutators, since the roles of fermions and bosons are properly preserved automatically with the interaction modeled by commutators. These operator representations of the particles are essentially a reinterpretation of the standard creation and annihilation operators where p^+ creates a proton (here it is a proton) and p^- annihilates a proton (here it is an antiproton). Then in this model,

$$\left[\pi^+, n\right] = p^+$$

$$\left[\pi^-, p^+\right] = n$$

Thus the π^+ replaces the τ^+ and the π^- replaces the τ^-. The bracket of π^+ and π^- should then play the role of τ_3.

$$\left[\pi^+, \pi^-\right] = \gamma_4 - \gamma_2$$

$$[\gamma_4 - \gamma_2, n] = -n$$

$$[\gamma_4 - \gamma_2, p^+] = p^+$$

Showing that $\gamma_4 - \gamma_2$ generates the quantum numbers and thus replaces the τ_3. Then we have:

$$[\gamma_4 - \gamma_2, \pi^+] = 2\pi^+$$

$$[\gamma_4 - \gamma_2, \pi^-] = -2\pi^-$$

Since we are no longer treating the proton and the neutron as different states of the same particle, the term isospin is no longer appropriate. The corresponding symmetry in the model under discussion is generated by the pion and anti-pion, thus the term pi-sospin seems more appropriate. The introduction of new terminology will also help us clarify issues which arise when comparing the present model of matter to the old theory. The proton then has pi-sospin +1, the neutron has pi-sospin -1, π^+ has pi-sospin +2 and the π^- has pi-sospin -2. The isospin (I_3) of these particles is one half the pi-sospin. This is required to obtain eigenvalues of 1, 0 and -1 for each γ_i. We need the eigenvalues to be integral values of the charges.

In the standard model, according to Perkins [22]:

> For the strange particles, note first that the Λ-hyperon has no charged counterpart, implying $I_\Lambda = 0 \ldots$ The values of I and I_Λ involved in decay are as follows:
>
> $$\begin{array}{cccccc} & \Lambda & \rightarrow & p & + & \pi^- \\ I & 0 & & \frac{1}{2} & & 1 \\ I_3 & 0 & & \frac{1}{2} & & -1 \end{array}$$
>
> This is a *weak* decay process and neither I nor I_3 are conserved on the two sides of the equation.

In the picture presented in [16, 17], the Λ was shown to be an excited neutron and consequently has the same pi-sospin as the neutron, -1, and the "pi-sospin" is conserved in all interactions.

Perkins [22] goes on to argue that the K^+-meson has $I_3 = +\frac{1}{2}$, however in [17] the K^+-meson is shown to be an excited state of the π^+ and has the same pi-sospin as the π^+, namely 2.

2 Pi-sospin of the fundamental particles

We have computed the pi-sospin of the proton, the neutron, the pion and their anti-particles. Pi-sospin and isospin agree (up to the factor of 2) on those particles. Now we turn to the other particles in the matter matrix. Isospin and strangeness are only defined for particles which partake in the strong interaction; pi-sospin is defined for all particles. Isospin is not conserved in electromagnetic or weak interactions; pi-sospin is conserved in all interactions.

In 1956, Yasuhisa Murai [20] saw the need for such a redefinition of what was then called "isobaric spin":

> As the attempts at the classification of heavy particles are usually based upon the extension of charge independence, they are powerless in characterizing the decay interaction of heavy mesons into leptons, the concept of isobaric spin not being applicable to the lepton family. It will be a clue for future theory to search a formalism which replaces that of isobaric spin and is applicable both to baryons and leptons.

Such a theory is at hand and the numbers are easily calculated:

$$[\gamma_4 - \gamma_2, \nu] = \nu$$

$$[\gamma_4 - \gamma_2, \bar{\nu}] = -\bar{\nu}$$

Thus, the neutrino has pi-sospin 1.

$$[\gamma_4 - \gamma_2, H] = 0$$

$$\left[\gamma_4 - \gamma_2, \bar{H}\right] = 0$$

The Hydrogen atom has pi-sospin 0.

$$\left[\gamma_4 - \gamma_2, e^-\right] = -e^-$$

$$\left[\gamma_4 - \gamma_2, e^+\right] = e^+$$

The electron has pi-sospin -1.

In their 1963 paper de Broglie, Bohm et al [1] ascribed "isobaric spins and strangeness to leptons" but their numbers are not in agreement with the values assigned here.

3 Pi-sospin of the strange particles

The calculation of the pi-sospin of the proton, the neutron and the pion was an important prelude to computing the pi-sospin of the strange particles since all particles are built from these building blocks.

The strange particles (and their analysis using the quantum numbers from [17]) are:

K^0 has pi-sospin 0 but it was assigned an isospin (I_3) value of $-\frac{1}{2}$.

K^+ is an excited state of π^+ and hence has the same pi-sospin as the π^+, 2; but it was assigned an isospin of $\frac{1}{2}$.

K^- is an excited state of π^- and hence has the same pi-sospin as the π^-, -2 ; but it was assigned an isospin of $-\frac{1}{2}$.

Λ^0 is an excited state of the neutron and hence possesses the same pi-sospin as the neutron, -1 ; but it was assigned isospin 0.

Σ^+ is an excited state of the proton and hence has the same pi-sospin as the proton, 1; but it was assigned isospin 1 (the isospin value should be half the pi-sospin).

Σ^0 is an excited state of the neutron and hence has the same pi-sospin as the neutron, -1; but it was assigned isospin 0.

As shown in [17] Σ^-, Ξ^- and Ω^- all have the same algebraic factor as

$$n \otimes \pi^- \equiv \pi^- \otimes p^+ \otimes \pi^-$$

and hence their pi-sospin is 2 times the pi-sospin of the π^- plus the pi-sospin of p^+ which is 2(-2) + 1 = -3. However, the Σ^- was assigned isospin -1; the Ξ^- was assigned isospin $-\frac{1}{2}$ and the Ω^- was assigned isospin 0.

Many more examples could be given, but these clearly show that the isospin values assigned to numerous elementary particles in the standard model are wrong. Isospin is not conserved in the electromagnetic and weak interactions because the particles have been assigned the wrong isospin values. Strangeness is defined in terms of isospin, making the assignment of strangness numbers problematic.

Since the pi-sospin algebra is generated by interaction with pions and exponentiating a pion does not make sense, it seems that only the Lie algebra structure is meaningful and there is no corresponding Lie group directly involved with elementary particle interactions. This idea has been around for a long time, for instance, the footnote on page 24 of Lipkin [14]):

> One may note here that the continuous group of isospin transformations is very peculiar since they transform physical neutron

> states into states which contain linear combinations of neutrons and protons. Such linear combinations are never observed because of charge conservation and it has been suggested that such states do not exist in the Hilbert space describing physical states because of superselection rules. It is therefore perhaps satisfying that all of the useful isospin results can be obtained directly from the Lie algebra which involves only physical operators acting upon physical states and that the unphysical Lie group of continuous transformations is not required in order to obtain any of these results.

The implications of these results are immense: Noether's theorem demands a continuous group action for each conserved quantity in a Lagrangian Field theory. Since we have conserved quantities (charge, baryon number, lepton number and meson number) without a corresponding continuous group action, we cannot be working with a Lagrangian Field Theory. However, according to Bryce DeWitt:

> The very first and most fundamental assumption of the quantum theory is that every isolated dynamical system is describable by a characteristic *action functional S*.

If DeWitt is correct, the very foundation of quantum theory comes into question.

The setting required is that suggested by Sternberg [24]:

> ...the stage setting for dynamics will be a general symplectic manifold...It is only with the introduction of such spaces into mechanics that one can find the classical formulations of such notions as spin. In admitting these types of mechanical systems, one must reject the Lagrangian and, therefore, the variational formulation of mechanics, but substitute for it a formulation which is more in character with symplectic geometry.

In the present case, the symplectic manifold is $U(3,2)/U(3,1)\times U(1)$. The conserved quantities will not be generated via Noether's Theorem (since there is no Lagrangian) but rather by eigenvalue equations involving the Cartan subalgebra and the generalized Casimir operators of $U(3,2)$. Fortunately this program actually yields more conserved quantities.

4 Assignment of Quantum Numbers

The standard approach to the assignment of quantum numbers, according to Roman [23]:

> The principles according to which we shall assign isospin to the various particles are the following. If we have a group of particles with very nearly the same mass and other properties, then we shall consider them as components of an "isobaric multiplet". If the number of members is $(2t + 1)$, then t is the isospin of the multiplet.

Assignment of isospin in this manner has led to a quantum number which is not defined for all particles and is not conserved in electromagnetic or weak interactions. A truly conserved quantity must be defined for all particles and must be conserved in all interactions. Thus, the standard assignments of isospin and strangeness quantum numbers are not acceptable, which leads us to reject the standard way of classifying elementary particles as multiplets in representation spaces of a group. The representations are still with us, however, as the wave functions of the particles will prove to be in the eigenfunction representation of $u(3, 2)$.

$U(3, 2)$ is a noncompact group and noncompact groups were not considered in the multipet picture because unitary representations of noncompact groups are infinite dimensional and would lead to an infinite number of particles with the same mass. That problem does not exist in the present model.

Heisenberg [7] concluded that the proton and the neutron interacted by an exchange force. Yukawa [27] later proposed that the neutron and the proton in a nucleus were exchanging the particles now known as pions.

We interpret the pi-sospin relations to mean that what appears to be a n- p^+ system is in reality two protons exchanging a real (not virtual) π^-:

$$n \otimes p^+ \equiv p^+ \otimes \pi^- \otimes p^+$$

This is close in spirit to the result Heisenberg expected: the exchange of a "spinless electron obeying Bose statistics", although he thought that a positively charged particle was being exchanged.

According to Landau and Smorodinsky [12]:

> The existence of exchange forces is related to the high degree of similarity between the proton and neutron—it is believed that

> when these particles are in close proximity a light charged particle is transferred from the proton to the neutron (or from the neutron to the proton), thereby changing the charge states. The existence of these charged particles is now unquestioned: these are the so-called π-mesons...

Thus the nuclear pion hypothesis is an old idea, replacing the earlier nuclear electron hypothesis [25].

In the standard model, the (nn) and (pp) forces are assumed to be the same in spite of what Evans [5] calls the

> ...one piece of negative evidence, the nonexistence of a stable di-neutron.

He fails to mention the nonexistence of a stable di-proton.

The present hypothesis, that there are no neutrons in the nucleus rather the neutrons dissociate into a pion and a proton also goes against the standard hypothesis as stated by Evans [5]:

> We assume throughout that if a neutron, proton, electron, neutrino, or meson enters a nucleus, the particle retains its identity and extra-nuclear characteristics of spin, statistics, magnetic moment, and rest mass.

Li and Machleidt [13] presented evidence against the charge symmetry of the strong nuclear force. Kudryavtsev et al [10] observed "charge-symmetry violation in pion scattering from three-body nuclei."

In the present model, the strong force in a (pn) is due to the exchange of a real pion between two protons, in a (pp) system there are no pions, hence no strong force. In an (nn) there would be two protons exchanging two pions. Then there is no charge-symmetry in nuclear reactions.

Roman [23] notes

> ...the Λ is in many respects very similar to the neutron (for instance, it can replace a neutron in an atomic nucleus).

But rather than accept the obvious, that a Λ is an excited state of a neutron, it was identified as an isospin singlet. This is an obvious prejudice towards accepting the model in spite of the evidence.

Jauch and Rohrlich [9] observed:

> . . . the muon is known from its magnetic moment to be correctly described as a "heavy electron". . . (pp.536-37)

Niels Bohr [2] observed that the goal of science is "the gradual removal of prejudices." In a similar analysis, Paul Dirac [3] wrote:

> When one looks back over the development of physics, one sees that it can be pictured as a rather steady development with many small steps and superposed on that a number of big jumps. . . These big jumps usually consist in overcoming a prejudice. . . And then a physicist. . . has to replace this prejudice by something more precise, and leading to some entirely new conception of nature.

Lubkin [19] presented "a broad proof of the validity of superselection rules for all additive conserved quantities" but then not believing in the mathematics, went on to refute his own argument. This is a rare case where the prejudice is clearly revealed and Lubkin himself called this refutation "the dodge of vection V".

One's own prejudices are usually harder to identify and even harder to overcome. Indeed, these calculations could have been done in [16] but were not since it seemed that isospin was irrelevant in the new model of matter since the proton and neutron were not different states of the same particle. One of the requirements often set for a unification group is that it be simple [15]. It became necessary to abandon that requirement in order to obtain the five γ_i acting individually. Overcoming a prejudice is really just questioning what one has been taught, a necessary requirement for progress.

Prejudices are often reflected in the attitude: "We understand that already, we don't need to re-examine it. Why question something which everyone believes is correct?"

Yuval Ne'eman [21] answered that sort of thinking when he wrote:

> Between 1955 and 1971 the 'consensus' in our field *erred* badly. In the USA, especially in the West, Relativistic Quantum Field Theory was considered as "plain wrong" and useless. It was only because Holland and the USSR were outside the direct influence of that consensus that work continued on field theory and finally won. Beware of the consensus!

Now the consensus is Relativistic Quantum Field Theory and the Standard Model. Beware of the consensus!

5 The Pion Subalgebra

We will use the term "pion subalgebra" to mean the subalgebra generated by the pion and antipion. Similar terminology applies to the other particles. We begin with the actions of the pion and the antipion we have already discussed:

$$[\pi^+, n] = p^+$$

$$[\pi^-, p^+] = n$$

and the corresponding antiparticle transformation:

$$[\pi^-, \overline{n}] = p^-$$

$$[\pi^+, p^-] = \overline{n}$$

Which means that n dissociates into $\pi^- \otimes p^+$ and π^- becomes an intermediary between two p^+:

$$n \otimes p^+ \equiv p^+ \otimes \pi^- \otimes p^+.$$

This is the nuclear "exchange force" except that now it is between protons rather than between protons and neutrons. It seems appropriate to speak of the protons exchanging a pion, since the pion is so much lighter than the protons. The concept requires some modification when the intermediary particle is much heavier that the particles it holds together. The actions on the other particles are given by:

$$[\pi^+, e^-] = -\nu$$

$$[\pi^-, \nu] = -e^-$$

We next look at the corresponding antiparticle transformation:

$$[\pi^-, e^+] = \overline{\nu}$$

$$[\pi^+, \overline{\nu}] = e^+$$

Which we interpret to mean that the e^- 'dissociates' into $\pi^- \otimes \nu$ and thus the π^- becomes an intermediary between two ν:

$$\nu \otimes e^- \equiv \nu \otimes \pi^- \otimes \nu$$

Clearly, for this to work, it must involve a heavy electron, the muon, μ^-.

6 The Electron Subalgebra

The corresponding actions of the electron and the positron on H and p^+ is:

$$[e^+, H] = p^+$$

$$[e^-, p^+] = H$$

and the corresponding antiparticle transformation:

$$[e^-, \overline{H}] = -p^-$$

$$[e^+, p^-] = -\overline{H}$$

Which means that H dissociates into $e^- \otimes p^+$ and e^- becomes an intermediary between two p^+:

$$H \otimes p^+ \equiv p^+ \otimes e^- \otimes p^+.$$

This is the familar "exchange force" between atoms. It seems appropriate to speak of the protons exchanging an electron, since the electron is so much lighter than the protons. Then the actions on the other particles are given by:

$$[e^+, \nu] = \pi^+$$

$$[e^-, \pi^+] = \nu$$

We next look at the corresponding antiparticle transformation:

$$[e^+, \pi^-] = -\overline{\nu}$$

$$[e^-, \overline{\nu}] = \pi^-$$

Which we interpret to mean that the π^- dissociates into $e^- \otimes \overline{\nu}$ and thus the e^- becomes an intermediary between two $\overline{\nu}$:

$$\overline{\nu} \otimes \pi^- \equiv \overline{\nu} \otimes e^- \otimes \overline{\nu}$$

Now we note that

$$[e^-, e^+] = \gamma_1 - \gamma_4$$

At this point we could compute the spectrum of $\gamma_1 - \gamma_4$ and call it the electro-spin, in fact we could do the same for all the elementary particles and obtain the proto-spin, the Hydro-spin, and the nu-spin, but why? We have established that the spectra of γ_1,γ_2,γ_3 and γ_4 are fundamental and all the other linear combinations are secondary.

7 The Proton Subalgebra

The actions of the proton and the anti-proton are given by:

$$[p^-, n] = -\pi^-$$

$$[p^+, \pi^-] = -n$$

We next look at the corresponding antiparticle transformation:

$$[p^-, \pi^+] = -\overline{n}$$

$$[p^+, \overline{n}] = \pi^+$$

Which we interpret to mean that the n dissociates into $p^+ \otimes \pi^-$ and the p^+ is the intermediary between two π^-:

$$n \otimes \pi^- \equiv \pi^- \otimes p^+ \otimes \pi^-$$

Here, where the intermediary proton is much more massive than the pions, the terminology of "exchange force" seems inappropriate.

The action on the other particles:

$$[p^+, e^-] = -H$$

$$[p^-, H] = -e^-$$

and the corresponding antiparticle transformations:

$$[p^-, e^+] = -\overline{H}$$

$$[p^+, \overline{H}] = -e^+$$

Which means that the H dissociates into $p^+ \otimes e^-$ and the p^+ becomes the intermediary between two e^-:

$$H \otimes e^- \equiv e^- \otimes p^+ \otimes e^-$$

8 The Neutron Subalgebra

The action of the neutron and anti-neutron on positively charged particles is:

$$[n, \pi^+] = -p^+$$

$$[\overline{n}, p^+] = \pi^+$$

We next look at the corresponding antiparticle transformations:

$$[n, p^-] = -\pi^-$$

$$[\overline{n}, \pi^-] = p^-$$

Which we interpret to mean that n is the intermediary between two π^+.

$$p^+ \otimes \pi^+ \equiv \pi^+ \otimes n \otimes \pi^+$$

The $n \otimes \pi^+$ corresponds to a heavy proton.
Then the action on the other particles:

$$[n, \nu] = -H$$

$$[\overline{n}, H] = -\nu$$

and its antiparticle transformation

$$[\overline{n}, \overline{\nu}] = \overline{H}$$

$$[n, \overline{H}] = \overline{\nu}$$

Which means that n is the intermediary between two ν:

$$H \otimes \nu \equiv \nu \otimes n \otimes \nu.$$

9 The Neutrino Subalgebra

The action of the neutrino and anti-neutrino on the negatively charged particles is:

$$[\nu, \pi^-] = e^-$$

$$[\overline{\nu}, e^-] = \pi^-$$

We next look at the corresponding antiparticle transformation:

$$[\nu, e^+] = \pi^+$$

$$[\overline{\nu}, \pi^+] = -e^+$$

Which we interpret to mean that the π^- dissociates into $\overline{\nu} \otimes e^-$ and the $\overline{\nu}$ becomes the intermediary between two e^-.

$$e^- \otimes \pi^- \equiv e^- \otimes \overline{\nu} \otimes e^-$$

Then the action on the neutral particles:

$$[\nu, n] = H$$

$$[\overline{\nu}, H] = n$$

and its antiparticle transformation

$$[\overline{\nu}, \overline{n}] = -\overline{H}$$

$$[\nu, \overline{H}] = -\overline{n}$$

Which means that $\overline{\nu}$ is the intermediary between two H or that the ν is the intermediary between two n:

$$H \otimes n \equiv n \otimes \nu \otimes n$$

or

$$H \otimes n \equiv H \otimes \overline{\nu} \otimes H$$

This says that the $\overline{\nu}$ plays a role in atomic bonding while the ν plays a role in nuclear bonding. Neither of which is hinted at in the standard model. This interaction could provide a mechanism for fusion, starting with a hydrogen molecule which dissociates into two Hydrogen atoms:$H \otimes H$ then a neutrino-antineutrino pair is produced from kinetic energy with the ν escaping and the $\overline{\nu}$ bonding

$$H \otimes \overline{\nu} \otimes H$$

which then transitions to

$$H \otimes n$$

This interaction could take place at relatively low energies, requiring just enough thermal energy to change the electron in the hydrogen atom into a muon (a heavy electron in our picture).

10 The Hydrogen Subalgebra

The action of Hydrogen and anti-Hydrogen on negatively charged particles is:

$$[H, p^-] = e^-$$

$$[\overline{H}, e^-] = p^-$$

We next look at the corresponding antiparticle transformation:

$$[H, e^+] = -p^+$$

$$[\overline{H}, p^+] = -e^+$$

Which we interpret to mean that H is the intermediary between two e^+.

$$e^+ \otimes p^+ \equiv e^+ \otimes H \otimes e^+$$

$H \otimes e^+$ would correspond to a heavy p^+.

Then the action on the other particles:

$$[H, \overline{n}] = \nu$$

$$[\overline{H}, \nu] = \overline{n}$$

and its antiparticle transformation

$$[H, \overline{\nu}] = -n$$

$$[\overline{H}, n] = \overline{\nu}$$

Which means that H is the intermediary between two $\overline{\nu}$:

$$\overline{\nu} \otimes n \equiv \overline{\nu} \otimes H \otimes \overline{\nu}$$

11 Completing the Subalgebras

For each subalgebra, we have two of the generators, we need to find the others:

$$[p^-, p^+] = \gamma_3 - \gamma_4$$

$$[\pi^-, \pi^+] = \gamma_2 - \gamma_4$$

$$[e^-, e^+] = \gamma_1 - \gamma_4$$
$$[\nu, \overline{\nu}] = \gamma_1 - \gamma_2$$
$$[n, \overline{n}] = \gamma_2 - \gamma_3$$
$$[H, \overline{H}] = \gamma_1 - \gamma_3$$

In the standard approach, one defines the isospin generators τ_3 and $\tau_1 = (\tau^+ + \tau^-)$ and $\tau_2 = -i(\tau^+ - \tau^-)$. This leads to the physicist's version of su(2). Often, these operators are normalized with factors of $\sqrt{2}$. For our purposes, that is neither necessary nor desirable.

Following this standard construction, with τ^+ replaced by:

$$\pi^+ = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

and τ^- replaced by:

$$\pi^- = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

we obtain:

$$\tau_1 = (\pi^- - \pi^+)$$
$$\tau_2 = i(\pi^- + \pi^+)$$
$$\tau_3 = [\tau_1, \tau_2]$$

$$[\pi^+, \pi^-] = \gamma_2 - \gamma_4$$
$$= \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

This linear combination led to the physicist's version of $su(2)$, which is isomorphic to $so(3)$. Recall that physicists take the mathematician's version of the Lie algebra and multiply by i. There are other possible linear combinations of the π^+ and π^-.

The mathematician's version of $su(2)$ is obtained with:

$$\sigma_1 = (\pi^- - \pi^+)$$

$$\sigma_2 = i(\pi^- + \pi^+)$$

$$\sigma_3 = [\sigma_1, \sigma_2]$$

While another linear combination:

$$\rho_1 = (\pi^- + \pi^+)$$

$$\rho_2 = i(\pi^- - \pi^+)$$

$$\rho_3 = [\rho_1, \rho_2]$$

gives the mathematician's version of $su(1,1)$. This last combination corresponds to the $u(3,2)$ generator.

Note that in order to obtain $su(3,2)$ as suggested by the author, the electrically charged particles must lead to a noncompact $su(1,1)$ subalgebra while the electrically neutral particles lead to a compact $su(2)$ subalgebra. This is appropriate since the description of electromagnetism and gravity require the Lorentz group which is noncompact. This could possibly be an explanation of why the electromagnetic and gravitational interactions are long range (noncompact) while the other interactions are short range (compact).

12 Conclusions

All the analogues of pi-sospin are derived from the difference of two γ_i. It is the five γ_i which generate the quantum numbers and which govern the interactions. The fifth, γ_5, which was not discussed in this article, is the graviton.

Quang Ho-Kim and Pham Xuan Yem [8] state:

> Isospin is conserved in the strong interactions, but not in the electromagnetic and weak interactions. We give a brief discussion of how and where the symmetry is violated; the missing 'why' should be found in a future interaction model.

The interaction model discussed here has offered an explanation of the missing 'why'. Isospin is not conserved because it is not defined for all particles and the wrong values of isospin were assigned to many particles on the basis of an erroneous model. Replacing isospin by pi-sospin has led to a quantity which is conserved and which is defined for all particles. However, pi-sospin is defined in terms of other more fundamental operators in the model and is therefore not fundamental. So, the explanation of isospin violation has shown that the concept does not lead to new quantum numbers and isospin is therefore not fundamental.

In standard QFT, interactions are supposedly due to the exchange of Bosons. The idea of exchange forces was borrowed from the ideas of chemical bonds which are due to the exchange of electrons, which are Fermions. The model introduced here shows that other Fermions are also involved in exchange forces.

Kursunoglu [11] suggested that

> ...the pions π^+ and π^- are deeply bound states of two orbitons, viz.,
>
> $$\pi^+ = (e^+\nu_e) \qquad \pi^- = (e^-\overline{\nu}_e)$$

Kursunoglu also suggested that "...a neutron is a deeply bound state of $p, e, \overline{\nu}_e$." The advance made here is to replace the suggestive parenthesis by the geometric Lie bracket.

References

[1] Louis de Broglie, David Bohm, Pierre Hilton, Francis Halbwachs, Takehiko Takabayasi and Jean-Pierre Vigier; "Rotator Model of Elementary Particles Considered as Relativistic Extended Structures in Minkowski Space"; Phys. Rev. **129**, 1961, 438-450

[2] Niels Bohr, *Atomic Physics and Human Knowledge*, Wiley, 1958, p. 31

[3] P. A. M. Dirac, Development of the Physicist's Conception of Nature; in J. Mehra (ed.), *The Physicist's Conception of Nature*; D. Reidel Publishing Company, 1973

[4] Bryce S. DeWitt, Dynamical Theory of Groups and Fields; in C. DeWitt and B. DeWitt(eds.) *Relativity Groups and Topology*, Gordon and Breach, 1964

[5] Robley D. Evans, *The Atomic Nucleus*, McGraw-Hill, 1955

[6] Rudolph Haag, "Observables and Fields," in *Lectures on Elementary Particles and Quantum Field Theory, Volume 2*, edited by S. Deser et al, M.I.T. Press, 1970

[7] W. Heisenberg, "On the structure of the atomic nucleus", Z. Phys., **77**,1932 1-11

[8] Quang Ho-Kim and Pham Xuan Yem, *Elementary Particles and their interactions*, Springer, 1998

[9] J.M. Jauch and F. Rohrlich, *The Theory of Photons and Electrons*, Springer-Verlag, 1976

[10] A. E. Kudryavtsev, V.E. Tarasov, B.L. Berman, W.J. Briscoe, K.S. Dhuga and I.I. Strakovsky et al "Charge-symmetry violation in pion scattering from three-body nuclei", Phys. Rev. *C 66*, 054007, 2002

[11] Behram Kursunoglu, "A NON-TECHNICAL HISTORY OF THE GENERALIZED THEORY OF GRAVITATION DEDICATED TO THE ALBERT EINSTEIN CENTENNIAL"; in *On the Path of Albert Einstein*, ed. A. Perlmutter and L.F. Scott, Plenum Press, 1979

[12] L. Landau and Ya. Smorodinsky, *Lectures on Nuclear Theory*, Plenum Press, 1959

[13] G.Q. Li and R. Machleidt, "Charge asymmetry of the nucleon-nucleon interaction," Phys. Rev. **C58**,1998,1393-1402

[14] Harry Lipkin, *Lie Groups for Pedestrians, Second Edition*, North-Holland Publishing, 1966

[15] Thomas R. Love, "The Geometry of Grand Unification",Int. J. Th. Phys. **23**,801,1984

[16] Thomas R. Love, *The Geometry of Elementary Particles*, Dissertation, University of California at Santa Cruz, 1987

[17] Thomas R. Love, "Complex Geometry, Gravity and Unification", I. The Geometry of Elementary Particles; Int. J. Th. Phys. **32**,1993, 63-88, II. The Generations Problem, Int. J. Th. Phys. **32**,1993, 89-107.

[18] Thomas R. Love, "Elementary Particles as Oscillations of Anti-de Sitter Space-Time," in preparation.

[19] Elihu Lubkin, "On Violation of the Superselection Rules"; Annals of Physics,**56**,1970, 69-80

[20] Yasuhisa Murai, "Inversion in the Isobaric Spin Space", Nuc. Phys. **1**,1956, 657-659

[21] Yuval Ne'eman, "Hadron Symmetry, Classification and Compositeness." *Proc Intern Conf on the History of Scientific Ideas*, (Barcelona),1987, 499-540

[22] Donald H. Perkins, *Introduction to High Energy Physics*, Addison-Wesley, 1972

[23] Paul Roman, *Theory of Elementary Particles*, North-Holland Publishing, 1960

[24] Shlomo Sternberg, "On the Role of Field Theories in our Physical Conception of Geometry"; in *Differential Geometric Methods in Mathematical Physics II*, K. Bleuler, H. R. Petry and A. Reetz(eds), Lecture Notes in Mathematics 676, Springer, 1978

[25] Roger Stuewer, "The Nuclear Electron Hypothesis"; in *Otto Hahn and the Rise of Nuclear Physics*,W. Shea (ed.), D. Reidel Publishing, 1983

[26] C.N. Yang, "Symmetry and Physics", in *The Oskar Klein Memorial Lectures*, Vol. 1 Editor: G. Ekspong, World Scientific, 1991

[27] H. Yukawa, Proc. Phys. Math. Soc. Japan **17**,1935, 48