

# A Preon Model for Particles and Forces, based on Modified Electric Charge

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**Abstract.** A simple model is proposed in which quarks and leptons are composed of preons that carry only electric charge. But electric charge is modified so that it comes in three varieties. All short-range forces are transmitted through exchange of massive bosons that are themselves composed of preons. The massless bosons that mediate the long-range forces are not composed of preons.

Note: This article is an improved version, with new material, of the [article](#) posted in May 2024 at viXra.org.

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## Introduction

In the Standard Model of particle physics, quarks and leptons are considered to be elementary particles with no internal structure. However, many authors have proposed models in which these particles are built out of smaller particles called preons [1]. The constituent preons making up a quark or lepton would obviously need to be bound together by a new force. There is variety in the proposed models about the charges and properties of preons, in what numbers and how they combine to yield quarks and leptons, and by what force they are bound together.

In an early model known as the Rishon model [2], two types of preon were proposed, one carrying an electric charge of  $+1/3e$  and the other being neutral, together with their antiparticles. A quark or lepton is constructed from three preons or from three antipreons, but preons and antipreons cannot be mixed together in an individual quark/lepton. Preons and antipreons also carry colour charges, which sum to colourless in leptons, but sum to a net colour in quarks. In addition, a new hypercolour charge is carried by preons/antipreons, which gives rise to a hypercolour force that binds three constituent preons or antipreons together.

More recent preon models [3], [4], [5], tend to be more complex. Preons were introduced to simplify the Standard Model, not to make it more complex.

In this article I am proposing a preon model that is extremely simple, in which preons carry only electric charge. But I have modified electric charge so that it comes in three different varieties. From this initial basis, I am able to show that there are six different preons, together with their antipreons, which can be combined in groups of three to yield the usual quarks and leptons. I am also able to account for the known forces, as well as deduce the new force binding the preons together. Chirality is not explicitly included in my model, although interactions involving neutral leptons can be explained by the preon composition of the involved particles.

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# Preons

## 1. Charges

There is only one type of charge - the electric charge (ie. no colour or weak charges). But electric charge comes in three different varieties called **species** (E1, E2, and E3). A charge can be positive or negative, and is assigned an arbitrary value of 1/2. There are thus six different **elementary charges**.

| Six Elementary Charges |        |        |
|------------------------|--------|--------|
| E1+1/2                 | E2+1/2 | E3+1/2 |
| E1-1/2                 | E2-1/2 | E3-1/2 |

Electric charge must be conserved separately for each one of the three electric species.

## 2. Preons

There are two different types of preon. An **electric preon** carries two elementary charges of unlike species and of like sign. A **dipolar preon** carries two elementary charges of unlike species and of unlike sign. There are thus twelve different preons, forming six preon-antipreon pairs.

| Six Electric Preons |      |      |      |
|---------------------|------|------|------|
| Name                | E1   | E2   | E3   |
| PE1                 | +1/2 | +1/2 |      |
| PE2                 |      | +1/2 | +1/2 |
| PE3                 | +1/2 |      | +1/2 |
| NE1                 | -1/2 | -1/2 |      |
| NE2                 |      | -1/2 | -1/2 |
| NE3                 | -1/2 |      | -1/2 |

| Six Dipolar Preons |      |      |      |
|--------------------|------|------|------|
| Name               | E1   | E2   | E3   |
| PD1                | +1/2 | -1/2 |      |
| PD2                |      | +1/2 | -1/2 |
| PD3                | -1/2 |      | +1/2 |
| ND1                | -1/2 | +1/2 |      |
| ND2                |      | -1/2 | +1/2 |
| ND3                | +1/2 |      | -1/2 |

PE = positive electric; NE = negative electric; PD = positive dipolar; ND = negative dipolar.

Preons are quite massive, but they are so small that they are effectively point particles. They are absolutely stable; the elementary charges of a preon cannot ever be altered.

## 3. Preons must have a sign

All preons must be of either positive or negative sign. The sign of electric preons is obvious. Dipolar preons need to have a sign assigned to them. Three (PD1, PD2, PD3) will be considered to be of positive sign; their

antipreons (ND1, ND2, and ND3) will be considered to be of negative sign.

#### 4. Preon groups

The twelve different preons can be divided into three preon groups according to the electric species they carry. The four preons forming a group carry elementary charges of the same two species.

| Three Preon Groups |                    |                    |
|--------------------|--------------------|--------------------|
| Group A<br>(E1/E2) | Group B<br>(E2/E3) | Group C<br>(E3/E1) |
| PE1                | PE2                | PE3                |
| PD1                | PD2                | PD3                |
| NE1                | NE2                | NE3                |
| ND1                | ND2                | ND3                |

#### 5. Preons aggregate together

Preons aggregate together spontaneously to form quarks and leptons, which together are referred to as **elementary fermions**.

Preons attract each other because the half-integer elementary charges they carry are reactive. This means that a half-integer charge of a particular electric species on one preon will attract another half-integer charge of the same electric species on another preon. The two charges will together have a net integer value of +1, -1, or 0 (depending on the sign of the two charges). This is a stable state, and the two associated charges will not attract further charges of the same species. Two charges summing to zero are much more stable than two charges summing to 1.

To build a stable particle, all three electric species (E1, E2, and E3) must be present, and each species must sum to a net integer value. This can be achieved by aggregating together three preons, specifically one from each of the three preon groups. The resulting particle is said to be in the **integer state**.

#### 6. Building integer states

Suppose we aggregate two preons belonging to the same preon group. Their charges will sum to an integer value for each of the two carried species. Therefore, adding an additional preon (from any preon group) cannot result in an integer state.

In fact, a particle in the integer state can be built only by aggregating together one preon from each of the three preon groups. Theoretically, there are 64 different integer states, each corresponding to a quark or lepton. In 48 of these states, the preons will be of both signs (ie. two preons of one sign and one preon of the other sign). In 16 of these states, the preons will be all of the same sign.

We now introduce an arbitrary rule.

Elementary fermions must be built ONLY using preons of same sign.

48 of the 64 possible integer states are thus disallowed; only the 16 integer states with preons of same sign are allowed. This rule simplifies the preon model, and renders it self-consistent and symmetrical.

Thus, to build a matter quark or lepton we must use three preons of the same sign, using one preon from each of the three preon groups.

In 4 of the 16 allowed integer states, all three electric species will have the SAME net integer value (including sign if applicable).

$E_1, E_2, E_3 = 0, 0, 0$  or  $+1, +1, +1$  or  $-1, -1, -1$ .

Such an integer state is referred to as a **singlet state**. This is an extremely stable configuration.

Later, we shall see that elementary fermions not in the singlet state also aggregate together to form more complex particles that are in the singlet state. This is because the singlet state is the state in which a particle has the highest possible stability.

|  |
|--|
| The singlet state confers maximal stability. |
|--|

# Quarks And Leptons

## 1. Building elementary fermions

Rules:

- (1) One preon from each preon group (A, B, C).
- (2) Preons must be all of same sign.

Applying these rules, we can construct sixteen different elementary fermions, each with a unique preon composition. All are in the integer state; four are in the singlet state.

Figure 1 (at end of article) shows the general structure of fermions. They are grouped into two families. One family (containing eight fermions) is constructed using preons of positive sign (top row); the other family (also containing eight fermions) is constructed using preons of negative sign (bottom row). Fermions come in four different flavours (vertical columns), distinguishable by the number of electric preons they contain.

Figure 2 shows the preon composition of all the sixteen different particles forming the first generation. Note that the eight fermions in one family are the antiparticles of the eight fermions in the other family.

## 2. Leptons

Leptons are in the singlet state. They are composed of preons of one type only.

Charged leptons have a net electric charge of  $1e$ ; each electric species has a net value of 1 (in arbitrary units). The positron consists of the three different electric preons of positive sign; the electron consists of the three different electric preons of negative sign.

| Positron |      |      |      |
|----------|------|------|------|
|          | E1   | E2   | E3   |
| PE1      | +1/2 | +1/2 |      |
| PE2      |      | +1/2 | +1/2 |
| PE3      | +1/2 |      | +1/2 |
|          | +1   | +1   | +1   |

| Electron |      |      |      |
|----------|------|------|------|
|          | E1   | E2   | E3   |
| NE1      | -1/2 | -1/2 |      |
| NE2      |      | -1/2 | -1/2 |
| NE3      | -1/2 |      | -1/2 |
|          | -1   | -1   | -1   |

Neutral leptons have a net electric charge of zero; each electric species has a net value of 0. The electron neutrino consists of the three different dipolar preons of positive sign; the electron antineutrino consists of the three different dipolar preons of negative sign.

| Electron Neutrino |      |      |    |
|-------------------|------|------|----|
|                   | E1   | E2   | E3 |
| PD1               | +1/2 | -1/2 |    |

| Electron Antineutrino |      |      |    |
|-----------------------|------|------|----|
|                       | E1   | E2   | E3 |
| ND1                   | -1/2 | +1/2 |    |

|            |             |             |             |
|------------|-------------|-------------|-------------|
| <b>PD2</b> |             | <b>+1/2</b> | <b>-1/2</b> |
| <b>PD3</b> | <b>-1/2</b> |             | <b>+1/2</b> |
|            | <b>0</b>    | <b>0</b>    | <b>0</b>    |

|            |             |             |             |
|------------|-------------|-------------|-------------|
| <b>ND2</b> |             | <b>-1/2</b> | <b>+1/2</b> |
| <b>ND3</b> | <b>+1/2</b> |             | <b>-1/2</b> |
|            | <b>0</b>    | <b>0</b>    | <b>0</b>    |

Note that a neutrino and an antineutrino have the same charge composition; each particle contains the six different elementary charges. The difference is in how these charges are distributed on three preons.

### 3. Quarks

Quarks are not in the singlet state. They are composed of both electric and dipolar preons. Each quark comes in three different isomeric forms, corresponding to three different preon compositions.

The U-quark has a partial electric charge of  $2/3e$ . It is composed of two electric preons and one dipolar preon, all of same sign. Two electric species have a net value of 1 (in arbitrary units), and one species has a net value of 0. The tables below show the preon composition of the three positive U-quarks.

Note: The isomeric form of a U-quark is labelled A, B, or C depending on the preon group to which the single dipolar preon belongs.

| <b>Positive U-Quark (A)</b> |             |             |             |
|-----------------------------|-------------|-------------|-------------|
|                             | <b>E1</b>   | <b>E2</b>   | <b>E3</b>   |
| <b>PD1</b>                  | <b>+1/2</b> | <b>-1/2</b> |             |
| <b>PE2</b>                  |             | <b>+1/2</b> | <b>+1/2</b> |
| <b>PE3</b>                  | <b>+1/2</b> |             | <b>+1/2</b> |
|                             | <b>+1</b>   | <b>0</b>    | <b>+1</b>   |

| <b>Positive U-Quark (B)</b> |             |             |             |
|-----------------------------|-------------|-------------|-------------|
|                             | <b>E1</b>   | <b>E2</b>   | <b>E3</b>   |
| <b>PE1</b>                  | <b>+1/2</b> | <b>+1/2</b> |             |
| <b>PD2</b>                  |             | <b>+1/2</b> | <b>-1/2</b> |
| <b>PE3</b>                  | <b>+1/2</b> |             | <b>+1/2</b> |
|                             | <b>+1</b>   | <b>+1</b>   | <b>0</b>    |

| <b>Positive U-Quark (C)</b> |             |             |             |
|-----------------------------|-------------|-------------|-------------|
|                             | <b>E1</b>   | <b>E2</b>   | <b>E3</b>   |
| <b>PE1</b>                  | <b>+1/2</b> | <b>+1/2</b> |             |
| <b>PE2</b>                  |             | <b>+1/2</b> | <b>+1/2</b> |
| <b>PD3</b>                  | <b>-1/2</b> |             | <b>+1/2</b> |
|                             | <b>0</b>    | <b>+1</b>   | <b>+1</b>   |

The D-quark has a partial electric charge of  $1/3e$ . It is composed of one electric preon and two dipolar preons, all of same sign. One electric species has a net value of 1 (in arbitrary units), and two species have a net value of 0. The tables below show the preon composition of the three positive D-quarks.

Note: The isomeric form of a D-quark is labelled A, B, or C depending on the preon group to which the single electric preon belongs.

| Positive D-Quark (A) |      |      |      |
|----------------------|------|------|------|
|                      | E1   | E2   | E3   |
| PE1                  | +1/2 | +1/2 |      |
| PD2                  |      | +1/2 | -1/2 |
| PD3                  | -1/2 |      | +1/2 |
|                      | 0    | +1   | 0    |

| Positive D-Quark (B) |      |      |      |
|----------------------|------|------|------|
|                      | E1   | E2   | E3   |
| PD1                  | +1/2 | -1/2 |      |
| PE2                  |      | +1/2 | +1/2 |
| PD3                  | -1/2 |      | +1/2 |
|                      | 0    | 0    | +1   |

| Positive D-Quark (C) |      |      |      |
|----------------------|------|------|------|
|                      | E1   | E2   | E3   |
| PD1                  | +1/2 | -1/2 |      |
| PD2                  |      | +1/2 | -1/2 |
| PE3                  | +1/2 |      | +1/2 |
|                      | +1   | 0    | 0    |

#### 4. Compatibility

Any two preons of same sign belonging to different preon groups are compatible with each other, and can be found together in at least one quark or lepton.

The two different preons of same sign that belong to the same preon group cannot be found together inside any fermion. Such pairs are called **incompatible preon pairs**.

Six incompatible preon pairs:

PE1 and PD1; PE2 and PD2; PE3 and PD3.

NE1 and ND1; NE2 and ND2; NE3 and ND3.

#### 5. Matter particles

Only matter particles in the singlet state can be observed in isolation.

Preons are not in the singlet state, so isolated preons can never be observed. They aggregate together to form quarks and leptons.

Leptons are in the singlet state. Consequently, (a) they can be observed as discrete particles; and (b) they do not aggregate together or with other particles.

Quarks are not in the singlet state. Consequently, (a) isolated quarks can never be observed; and (b) quarks must aggregate together to form more complex particles (baryons) that are in the singlet state.

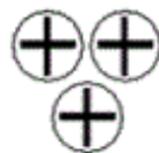
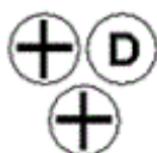
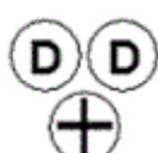
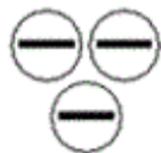
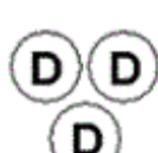
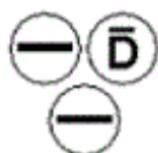
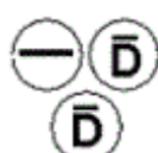
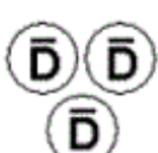
## 6. Forces

The forces that affect matter particles can be classified into two types.

**Preonic forces** originate directly from the elementary charges carried by preons. A preon can emit either one of the charges it carries together with its anticharge, or both of the charges it carries together with their anticharges. Three forces are generated by this mechanism, ie. the preon-binding force, the electromagnetic force, and the gravitational force. The bosons that transmit them are not composed of preons, and are massless.

**Secondary forces** arise when constituent preons inside elementary fermions are shuffled around by a mechanism driven by energy borrowed from the vacuum. One of these forces acts within elementary fermions, while the other forces ultimately act between elementary fermions. The bosons that transmit them are always composed of preons. They are thus massive and of short range. Those in the singlet state can be observed. A similar mechanism also operates at quark level.

Matter consists of elementary fermions built out of preons. The vacuum is an unobservable continuum full of energy, from which we can temporarily borrow virtual preon-antipreon pairs and quark-antiquark pairs. The interaction of vacuum energy (ie. borrowed particles) with material preons or quarks gives rise to forces. Matter particles in turn respond to forces.

**Figure 1 - Fermion Structure****Charged  
Lepton****U-type  
Quark****D-type  
Quark****Neutral  
Lepton****Positive****Positive****Positive****Neutrino****Negative****Negative****Negative****Antineutrino**

Preons:

Plus = positive electric preon.

Minus = negative electric preon.

D = positive dipolar preon.

D-bar = negative dipolar preon.

Net electric charge:

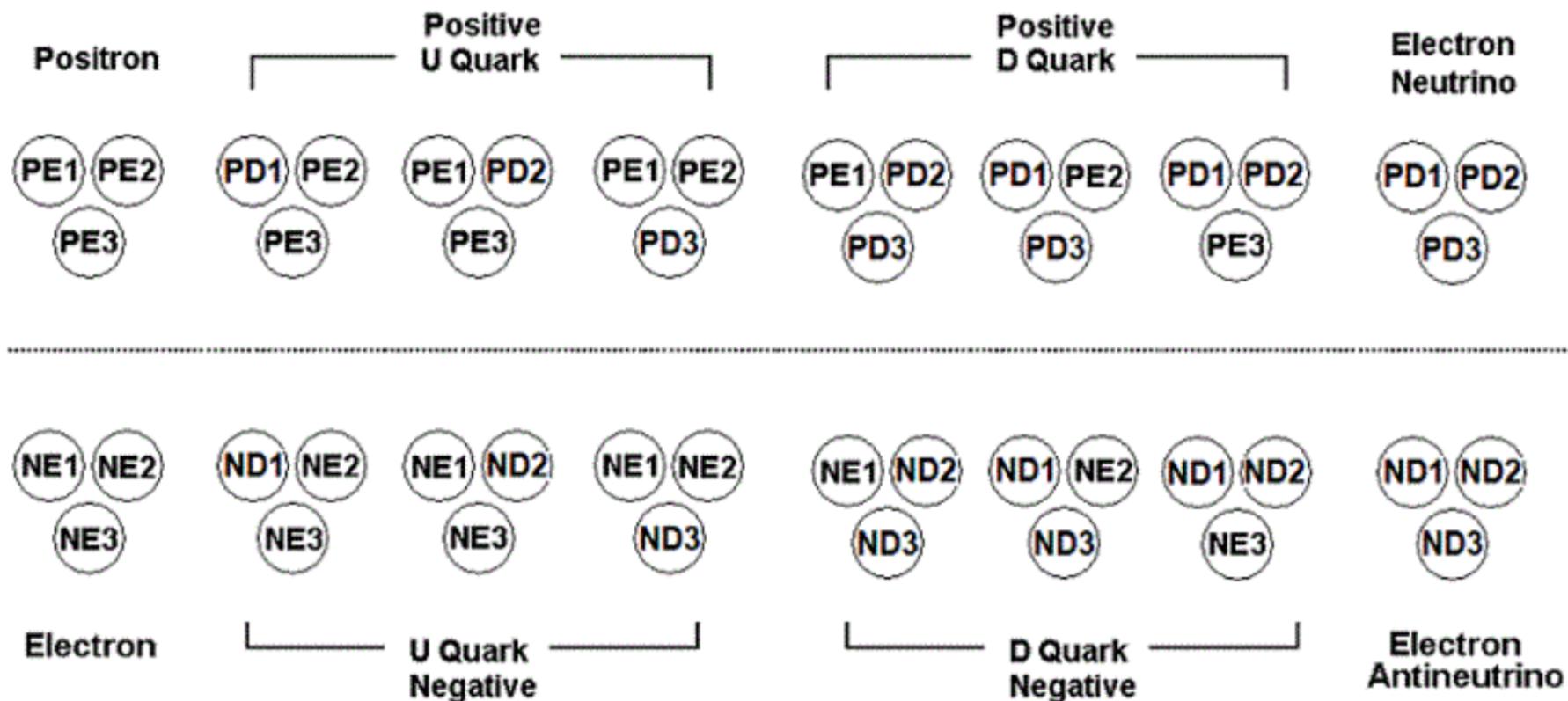
3 electric preons = 1e.

2 electric preons = 2/3e.

1 electric preon = 1/3e.

0 electric preons = no electric charge.

Figure 2 - Sixteen Elementary Fermions (First Generation)



# How Preons Bind Together

## 1. Introduction

The three constituent preons that make up any elementary fermion are bound together by the **preon-binding force**. They are bound so strongly that they are kept confined within the particle. Isolated preons can never be observed. This force arises directly from the elementary charges carried by preons, so it is classified as a preonic force. In brief, elementary charges of the SAME species attract each other, but elementary charges of different species do not interact. The preon-binding force is thus species specific.

## 2. Origin

The preon-binding force acts between charges of same species carried on different preons. Two charges of same species, whether of like or unlike sign, will attract each other. Two charges of different species do not interact at all.

A preon can emit one of the charges it carries together with its anticharge. It does this by borrowing a charge-anticharge pair of that electric species from the vacuum. The emitting preon will be left unchanged, carrying its original charges. The emitted charge-anticharge pair serves as the virtual boson that transmits the preon-binding force. This boson is called the **pb-boson** (pb stands for preon-binding), and has no net charge. Note that the pb-boson is not composed of preons, and is thus massless. It is always virtual, and is unobservable. There are obviously three different pb-bosons, one per electric species.

Example: NE1 preon emits an  $[E1-1/2][E1+1/2]$  pb-boson.

An emitted pb-boson can be absorbed only by a preon that carries a charge of the same electric species as carried by the pb-boson.

Example:  $[E1-1/2][E1+1/2]$  emitted by an NE1 preon can theoretically be absorbed (a) by group A preons PE1, NE1, PD1, ND1, or (b) by group C preons PE3, NE3, PD3, ND3. All these preons carry a charge of species E1.

When a pb-boson of a particular electric species reaches a preon that carries a charge of that same species, the boson is absorbed by the charge. The absorbing preon remains unchanged. Exchange of a pb-boson between two charges of the same electric species carried on two different preons will transmit the preon-binding force between the interacting charges. The two charges will attract each other. In consequence, the two preons on which the interacting charges are carried will attract each other. This force is extremely strong, and the two preons will aggregate together. Once aggregated, two paired charges (located on different preons) will not attract other nearby charges of the same species.

## 3. Same preon group

Two preons belonging to the same preon group carry charges of the same two species. So, when two such preons are near to each other, the two charges of same species (one on each preon) will constantly exchange pb-bosons between them. The two charges will attract each other and become bound together by the preon-binding force. This happens separately for each of the two carried species. The two preons will thus attract each other, and move ever closer together until they aggregate together. Obviously, the half-integer charges of each of the two carried species will sum to an integer value of 1 or 0. Each aggregated pair of charges will be 'satisfied', and will not attract other nearby charges of same species. As a result, the bound pair of preons will not attract any other nearby preon. It appears that matter particles composed of two preons belonging to the same preon group do not exist.

## 4. Different preon groups

Two preons belonging to different preon groups have only one electric species in common. So, the two charges of this in-common species (one on each preon) will attract each other. They will sum to a net integer value (0 or 1). But the other two charges (one on each preon), being of different species, will not attract each other. These two half-integer charges will be left unpaired. It appears that matter particles composed of two preons belonging to different preon groups do not exist.

The two preons belonging to different preon groups can however attract a third preon from the remaining preon group. All three species will then have paired charges of integer value. A stable state (integer state) is achieved, and no more preons will be attracted. Theoretically, the three preons so bound need not be all of the same sign. But for some reason, only preons of same sign aggregate together to form matter particles. These aggregated preons (one from each preon group) are then kept stably bound together by the preon-binding force.

Paired charges of the same species that are of unlike sign, summing to a value of 0, are much more stable than those of same sign that sum to a value of 1. This is why the mass of the neutral lepton is so much smaller than the mass of the charged lepton.

## **5. Most important force**

A matter particle is stable only if there are paired elementary charges (on different preons) for each one of the three electric species. The two charges in each pair are bound together by the preon-binding force. Since paired charges have a net integer value (0 or 1), a stable particle is always in the integer state.

The preon-binding force is theoretically of long range. But as soon as three preons - close to each other in space - aggregate together to form an elementary fermion, the force becomes confined to within the fermion. This is because paired charges of the same species within an elementary fermion do not attract other charges of the same species located outside the elementary fermion.

The preon-binding force is the most important force in this preon model. It is also the strongest force. Theoretically, a change in preon composition of a particle is possible only if the altered particle remains in the integer state (otherwise it would be unbound). The integer state must always be preserved, and this is ensured by the action of the preon-binding force.

## **6. Masses of quarks and leptons**

Leptons are in the most stable configuration possible (the singlet state), so their masses are low. In the neutral lepton, stability is maximal because the two elementary charges of same species sum to zero. The particle mass of the neutral leptons is thus vanishingly small. The mass of the charged lepton, on the other hand, is appreciable. This is because the two elementary charges of same species sum to 1, a less stable configuration. [Note: As we shall see later, electric preons of same sign within an elementary fermion do not repel each other electromagnetically].

Quarks are not in the singlet state, so they have much more energy than leptons. The mass of the U-quark and the D-quark is thus much higher than that of the electron. The U-quark appears to have a larger mass than the D-quark.

## **7. Particle generations**

A quark or lepton is made out of three preons that are bound together by the preon-binding force. In the ground state, the bound preons constitute a first-generation particle. Excited states of such a particle result in higher-generation versions of the same particle. For example, the electron, the negative muon, and the negative tauon all have the same preon composition of (NE1/NE2/NE3). In the ground state, the three constituent preons are maximally bound together. They are held quite close to each other, and so particle mass is low. This is the electron. When the three preons are energised, they move some distance apart. An excited state of higher mass thus results. This is the negative muon. Further excitation leads to a particle with still higher mass as the preons move further apart. This is the negative tauon.

A quark or lepton of higher generation can decay only if all three constituent preons lose energy at the same time. This can only be achieved through a decay involving the weak force, by emission of either a W-boson or a Z-boson.

## How Secondary Forces Arise

### 1. The basic mechanism

All secondary forces arise by the same basic mechanism, known as the **vacuum shuttle**. In some forces, the mechanism is the same but with a slight modification.

(a) Emission - The process starts when a preon-antipreon pair arises from the vacuum on borrowed energy, as per Heisenberg Uncertainty. This vacuum pair collides with a constituent preon at location X inside an elementary fermion. The collision causes a 'change of partner'. The constituent preon pairs up with one of the two preons making up the vacuum pair, forming a two-preon combination that is emitted and moves away from the collision site. The other member of the vacuum pair remains at the collision site at location X. The newly created two-preon combination can suffer one of two fates.

(b1) Reabsorption - The two-preon combination can move back to location X, and be absorbed by the new preon at the collision site. In this case a 'change of partner' occurs that returns the original constituent preon to its original location at X. At the same time, this also generates the exact same preon-antipreon pair that was borrowed from the vacuum. The vacuum pair is returned to the vacuum, extinguishing the energy debt. Reabsorption reverses all changes, so there is no net change. No force is transmitted.

(b2) Absorption - The emitted two-preon combination can travel to reach a second constituent preon at location Y inside the elementary fermion, which can absorb it. In this case, the two-preon combination constitutes a boson, which can transmit a secondary force. On absorption, a 'change of partner' occurs. The constituent preon at location Y will pair up with one of the two preons of the boson such that the preon-antipreon pair that was borrowed from the vacuum is formed anew. This preon-antipreon pair is returned to the vacuum. The constituent preon originally at location X, having been ferried across as part of the boson, is left behind at the absorption site as the new constituent preon at location Y. The interaction is now complete.

### 2. Weak preon force

We now discuss a secondary force called the **weak preon force**. This force acts only within an elementary fermion. It binds together the three constituent preons making up the fermion, but note that it is much weaker than the preon-binding force (which is a preonic force).

Let's examine how two electric preons of negative sign (NE1 and NE2) inside an electron are bound together by the weak preon force. The interaction (Figure 3 at end of article) occurs by exchange of a virtual massive boson called a **gluon**, which transmits the force. As a result of the interaction, the two preons exchange identity, and attract each other. Incessant interactions, two preons at a time involving all three constituent preons, help keep the three preons in the electron bound tightly together. Recall that the three preons are bound together mainly by the much stronger preon-binding force; the secondary weak preon force is weaker, but helps to bind the preons.

Gluon emission (Figure 4) occurs when an appropriate preon-antipreon pair (PE2/NE2) arises from the vacuum and collides with the NE1 constituent preon located at X. The 'change of partner' generates a gluon (PE2/NE1) while leaving the new preon NE2 at the collision site X. The gluon reaches constituent preon NE2 located at Y.

Note that the vacuum pair that collides with the 'emitting' constituent preon must be the specific one that includes a preon identical to the constituent preon that will absorb the gluon.

Gluon absorption (Figure 5) is essentially gluon emission in reverse. The gluon now collides with the constituent preon (NE2) at location Y. Again, a 'change of partner' occurs. The constituent preon (NE2) pairs up with its antipreon (PE2), forming the same preon-antipreon pair that was initially borrowed from the vacuum. This pair

returns to the vacuum. The other preon forming part of the gluon is left free as the new constituent preon (NE1) at location Y. The interaction is now complete.

The above interaction can be summarised as:

(NE1) at X + borrow[PE2][NE2] => (NE2) at X + gluon[PE2][NE1]  
 (NE2) at Y + gluon[PE2][NE1] => (NE1) at Y + return[PE2][NE2]

All preon interactions follow the above general pattern. At the end of an interaction, the two preons seem to have exchanged identity, or perhaps they just moved to each other's location. What really happens is that one interacting preon moves from X to Y, while the other leaves Y to disappear into the vacuum. The books are balanced because a preon coming from the vacuum, identical to the one that 'disappeared' at Y, becomes the constituent preon at X.

Thus constituent preons are constantly moving into the vacuum, and are replaced by preons coming from the vacuum. What we can observe, and call a matter particle, is a stable state of congealed energy which has definite properties (rest mass, intrinsic spin, electric charge). This pattern is maintained despite the continuous preon replacements. The pattern defines the particle.

### 3. Gluons

A gluon is composed of two preons of unlike sign that belong to different preon groups. There are 24 different gluons. Some have an electric charge ( $1/3e$ ) and some are neutral. In each gluon, one of the electric species comes as two paired half-integer elementary charges, which sum to a net value of 0 or 1. The charges of the other two species are unpaired, and are thus of half-integer value.

All possible interactions between different electric preons of same sign are mediated by six different neutral gluons. Each is composed of two electric preons of unlike sign.

| A Neutral Gluon (E-E) |      |      |      |
|-----------------------|------|------|------|
|                       | E1   | E2   | E3   |
| PE2                   |      | +1/2 | +1/2 |
| NE1                   | -1/2 | -1/2 |      |
|                       | -1/2 | 0    | +1/2 |

All possible interactions between different dipolar preons of same sign are mediated by a second set of six different neutral gluons. Each is composed of two dipolar preons of unlike sign.

| A Neutral Gluon (D-D) |      |      |      |
|-----------------------|------|------|------|
|                       | E1   | E2   | E3   |
| PD1                   | +1/2 | -1/2 |      |
| ND2                   |      | -1/2 | +1/2 |
|                       | +1/2 | -1   | +1/2 |

All possible interactions between an electric preon and a dipolar preon of same sign are mediated by twelve different charged gluons. Each is composed of an electric preon and a dipolar preon of unlike sign, and has a net electric charge of  $1/3e$  (six are positive and six are negative).

| A Charged Gluon |      |      |      |
|-----------------|------|------|------|
|                 | E1   | E2   | E3   |
| PE1             | +1/2 | +1/2 |      |
| ND2             |      | -1/2 | +1/2 |
|                 | +1/2 | 0    | +1/2 |

All gluons are unobservable, because they are not in the singlet state.

#### 4. Note on vacuum shuttle mechanism

Any preon-antipreon pair from the vacuum can collide with any constituent preon. So, any possible combination of two preons can be emitted. As we saw, some two-preon combinations are gluons that transmit the weak preon force. Within an elementary fermion, any two-preon combination (gluon or not) that is not or can not be absorbed by another constituent preon inside that same fermion, must be reabsorbed, ie. absorbed by the preon left behind at the emission site. No net change thus occurs.

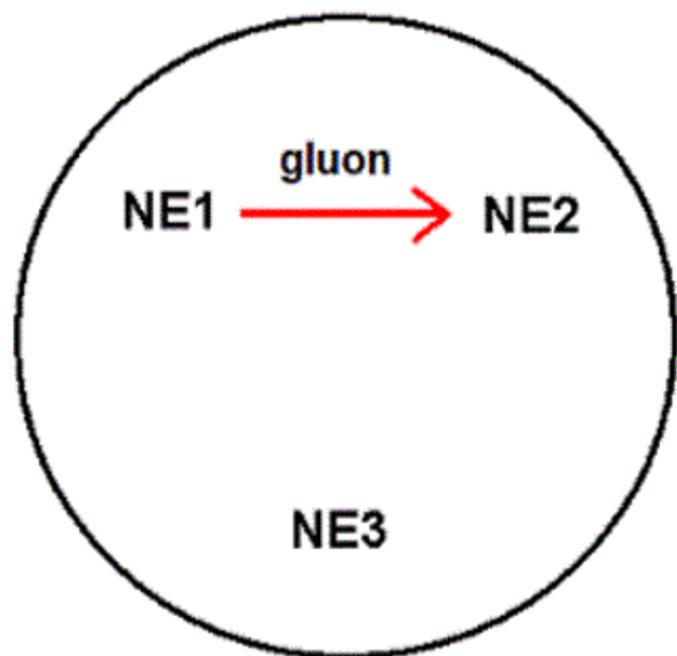
eg. (PE1) at X + borrow[PE2][NE2] => (NE2) at X + emit[PE1][PE2]  
 (NE2) at X + reabsorb[PE1][PE2] => (PE1) at X + return[PE2][NE2]

Note: When a preon is replaced with an identical preon, the borrowed preon-antipreon pair remains unchanged, and is returned immediately to the vacuum.

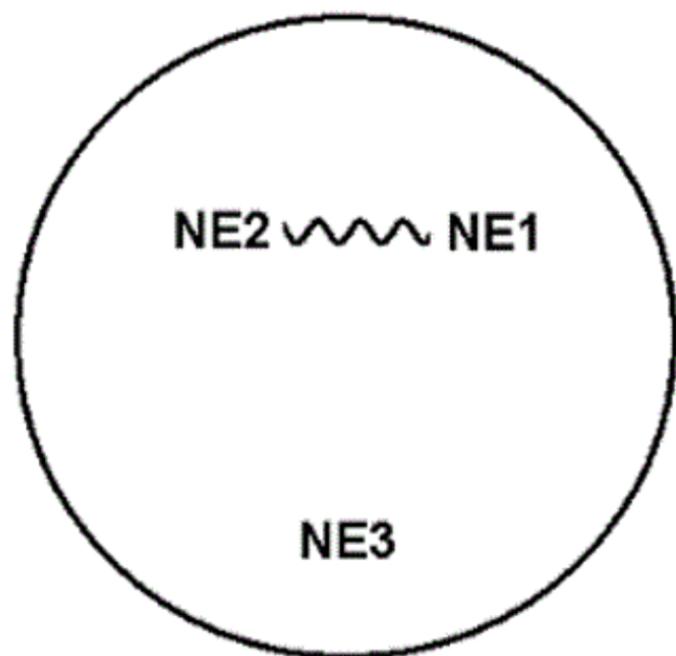
eg. (PE1) at X + borrow[PE1][NE1] => (PE1) at X + return[PE1][NE1]

In other articles we will see that some two-preon combinations (singly or in groups of three) can transmit secondary forces between elementary fermions.

**Figure 3 - Two Preons Interact Within An Electron**



**boson exchange**



**preons exchange identity**

Figure 4 - Gluon Emission

constituent  
preon



+

vacuum  
pair



new  
constituent  
preon



+

gluon

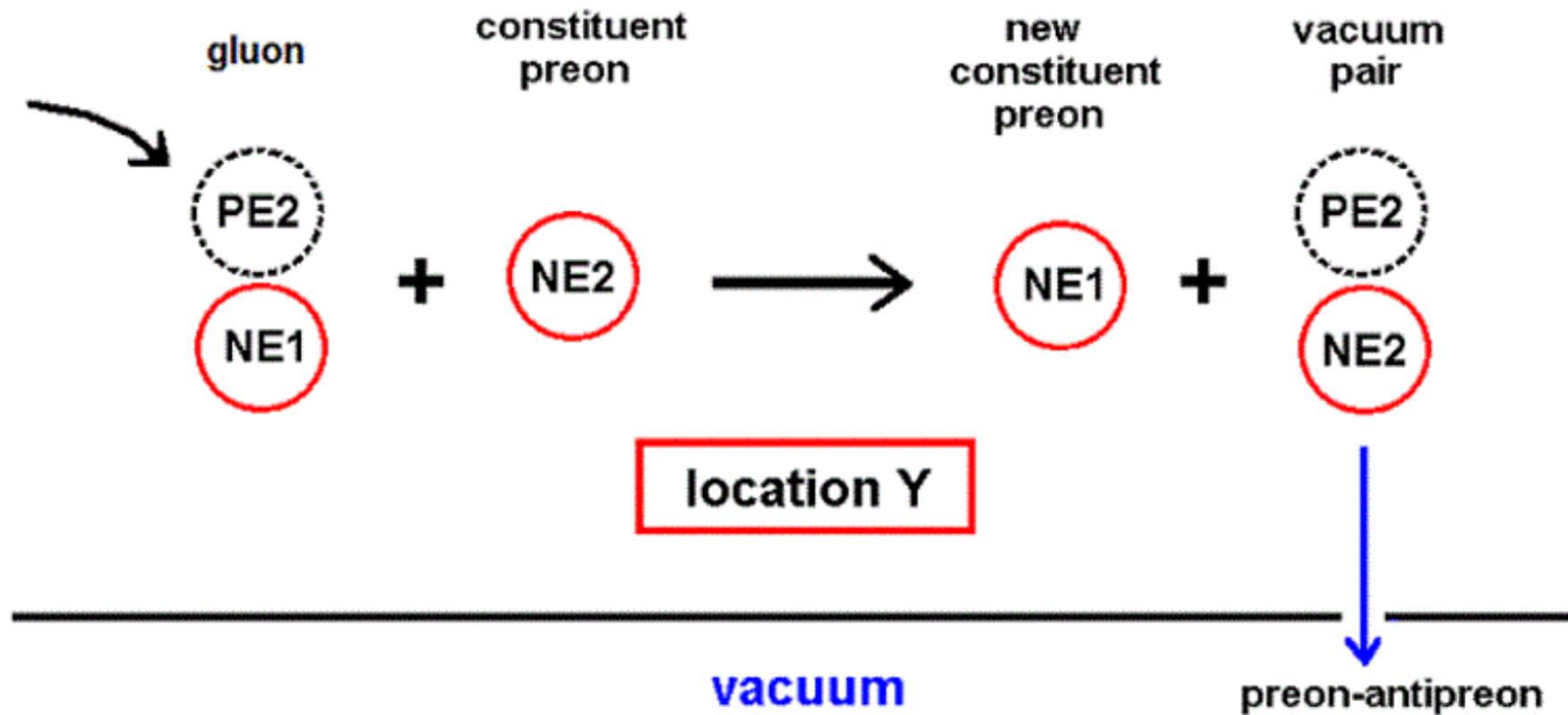


location X

preon-antipreon

vacuum

Figure 5 - Gluon Absorption



# Superweak Force

## 1. Introduction

Theoretically, if we remove a preon from an elementary fermion we can replace it only with a preon of same sign and same preon group. Either we replace it with a preon identical to it (with no net change), or we replace it with its incompatible preon-pair partner (resulting in change of flavour). So, if the two members of an incompatible preon pair are located in two separate elementary fermions, we could swap one member for the other. Both fermions would then change flavour. Such an interaction could theoretically be effected through exchange of a massive boson called the **X-boson**. Boson exchange would give rise to a short-range secondary force called the **superweak force**. There is no evidence that this force actually exists. Here we discuss it theoretically.

## 2. Superweak interactions

In a hypothetical superweak interaction (not considering mass), a preon located in an elementary fermion emits an X-boson and its incompatible preon-pair partner located in another elementary fermion absorbs it (Figure 6 at end of article). The interacting preons change into each other. Each interacting preon changes into its incompatible preon-pair partner.

The X-boson is generated by the vacuum shuttle. A constituent preon inside one elementary fermion collides with a preon-antipreon pair arising from the vacuum. The vacuum pair must be the specific one that contains the incompatible preon-pair partner of the constituent preon. The collision generates the X-boson, which is emitted out of the fermion and travels to reach a nearby fermion. The original constituent preon becomes part of the X-boson, and its incompatible preon-pair partner (originating from the vacuum) is left at the collision site.

Example:

(PE1) in fermion A + borrow[PD1][ND1] => (PD1) in fermion A + X-boson[PE1][ND1]  
 (PD1) in fermion B + X-boson[PE1][ND1] => (PE1) in fermion B + return[PD1][ND1]

The X-boson now collides with the 'absorbing' preon in fermion B. The 'emitting' constituent preon originally in fermion A is deposited at the collision site in fermion B. A preon-antipreon pair, identical to the one borrowed from the vacuum is formed, and is returned to the vacuum.

As a result of the boson exchange, the two interacting preons exchange identity. Each changes into its incompatible preon pair partner. Both interacting fermions change preon composition, change flavour, retain their sign, and remain in the integer state.

The two interacting preons attract each other through the transmitted superweak force. Consequently, the two fermions will also attract each other. But the attractive force is extremely weak. Interactions are extremely rare owing to the distance that separates the two interacting preons. The two fermions thus cannot be bound together.

## 3. X-bosons

An X-boson is composed of an electric preon and a dipolar preon of unlike sign belonging to the same preon group. There are six different X-bosons. They all have a net electric charge of  $1/3e$  (three are positive, and three are negative). An X-boson carries only two electric species, both of which have a net integer value.

| An X-boson |    |    |    |
|------------|----|----|----|
|            | E1 | E2 | E3 |

|            |             |             |  |
|------------|-------------|-------------|--|
| <b>PE1</b> | <b>+1/2</b> | <b>+1/2</b> |  |
| <b>ND1</b> | <b>-1/2</b> | <b>+1/2</b> |  |
|            | <b>0</b>    | <b>+1</b>   |  |

X-bosons are not in the singlet state, and are thus unobservable.

#### 4. Why the superweak force does not exist

We saw that the non-singlet gluons that help bind together constituent preons within an elementary fermion act only within the particle. They cannot be emitted away from the particle. Later we shall see that there are two massive bosons composed of preons that can be emitted away from an elementary fermion, and they can be observed (indirectly through their decay products). These two bosons - the W-boson and the Z-boson - are in the singlet state.

We shall see that the same occurs at the quark level. Quarks are bound together by non-singlet mesons (composed of two quarks) to form baryons. These mesons act within a baryon, but cannot be emitted away from it. In contrast, protons and neutrons are bound together by charged mesons that are in the singlet state. These mesons can be emitted outside a baryon. When energised, they can be observed.

So, it appears quite likely that a non-singlet X-boson cannot be emitted outside of an elementary fermion. The superweak force therefore cannot exist.

#### 5. Proton decay

Despite intensive searches, proton decay has not been detected. In this preon model, proton decay could potentially occur if the superweak force exists. Figure 7 shows how the two members of an incompatible preon pair (PE1 in one U-quark and PD1 in the other U-quark) could interact through the superweak force. The proton decays to a positron and a neutral meson (pi-zero). The same products result if the interaction occurs between preons PE2 and PD2 on the same quarks.

#### 6. Alternative mechanism

Perhaps the proton could decay through a superweak interaction involving a preon and its antipreon, this time located one in a U-quark and the other in the D-quark. Exchange of an X-boson between the two preons would transform the interacting preon-antipreon pair into the other preon-antipreon pair found in the same preon group. That is, the electric preon-antipreon pair in a preon group changes into the dipolar preon-antipreon pair belonging to that group, or vice versa. In this case the returned vacuum pair will differ from the borrowed pair. But note that each preon still changes into its incompatible preon pair partner.

If the superweak interaction involves an electric preon and its antipreon, the products would be an electron antineutrino and a charged meson (pi-plus). If the interaction involves a dipolar preon and its antipreon, the products would be a positron and a neutral meson (eta-zero).

**Figure 6 - A Superweak Interaction**

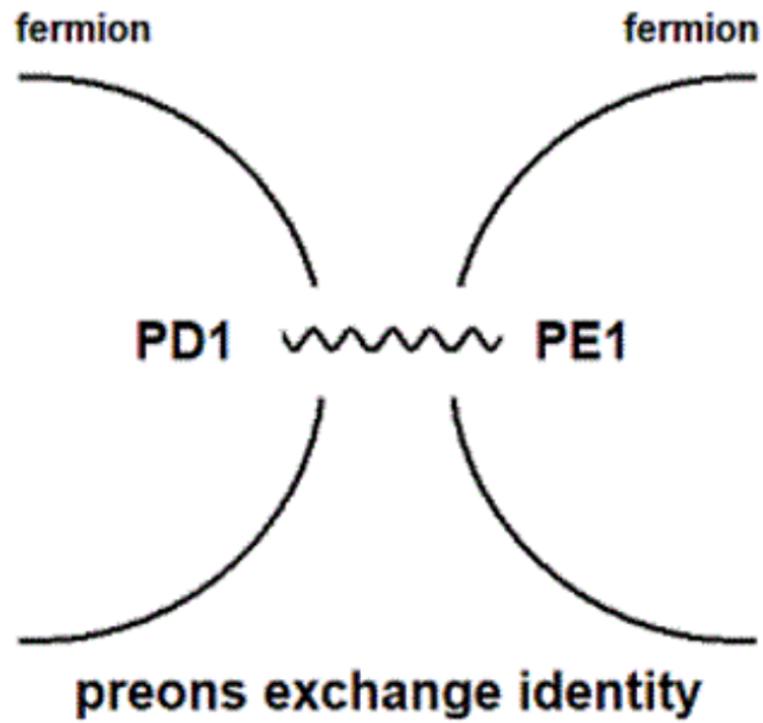
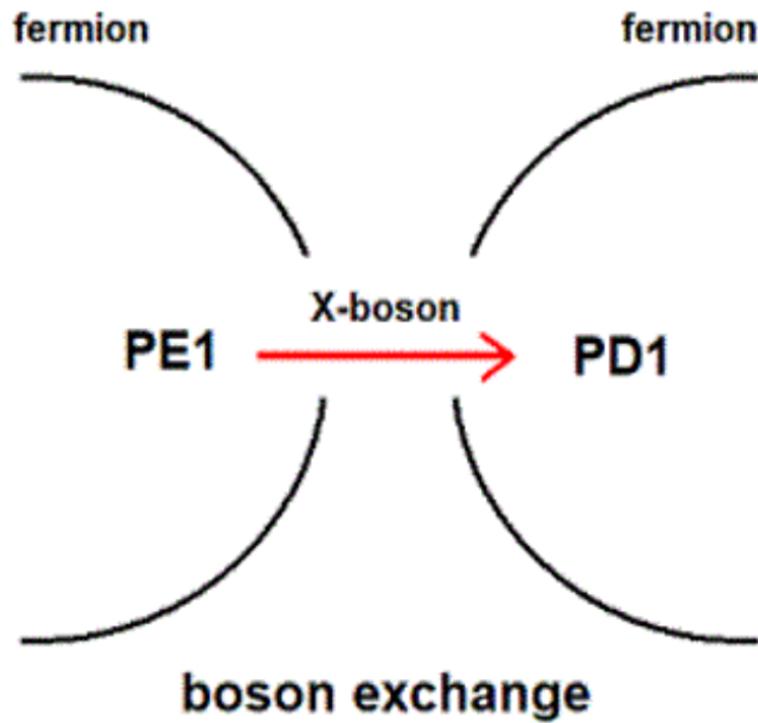
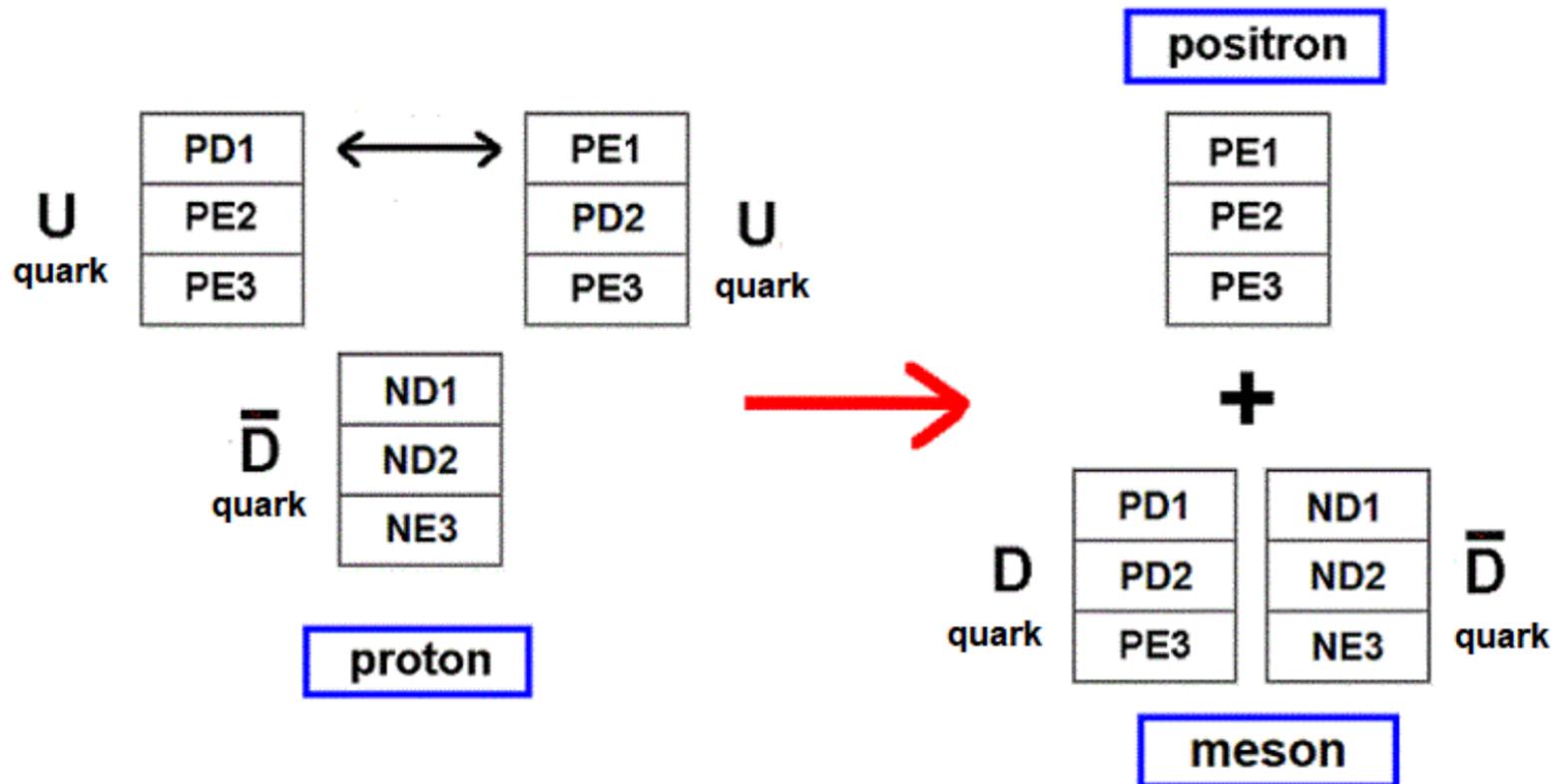


Figure 7 - Proton Decay



# Weak Charged Force

## 1. Introduction

The **weak charged force** is a secondary force transmitted by a massive boson called the **W-boson**. The boson is composed of preons and transmits the force between elementary fermions. This boson is in the singlet state. It can be created as a real particle in accelerator collisions, and can be observed (indirectly, through its decay products).

mass = 80 GeV; spin = 1; electric charge = +1e or -1e; range =  $10^{-16}$  cm; lifetime =  $10^{-25}$  s.

The weak charged force originates at the preon level. The W-boson is composed of the six different preons of same sign (see Figure 8 at end of article). This boson is generated when three **Y-bosons** combine.

## 2. Y-bosons

A Y-boson is composed of an electric preon and a dipolar preon of like sign belonging to the same preon group. It is thus composed of the two members of an incompatible preon pair. There are six different Y-bosons. All have a net electric charge of  $1/3e$  (three positive and three negative). A Y-boson carries only two electric species, both of which have a net integer value.

| A Y-boson |      |      |    |
|-----------|------|------|----|
|           | E1   | E2   | E3 |
| PE1       | +1/2 | +1/2 |    |
| PD1       | +1/2 | -1/2 |    |
|           | +1   | 0    |    |

Y-bosons are not in the singlet state, and are thus unobservable.

## 3. W-boson emission

A W-boson is generated when all three constituent preons are replaced by the antipreon of their incompatible preon-pair partner (eg. PE1 => ND1). Each preon emits a Y-boson; so, three different Y-bosons are generated. These three Y-bosons then associate together to form a W-boson, which is ejected from the elementary fermion. The W-boson is in the singlet state.

The Y-bosons are generated through the usual vacuum shuttle mechanism. Three preon-antipreon pairs must be borrowed from the vacuum. Each constituent preon interacts with one vacuum pair.

Example: Positron emits a W-plus.

(PE1) + borrow[PD1][ND1] => (ND1) + Y-boson[PE1][PD1]

(PE2) + borrow[PD2][ND2] => (ND2) + Y-boson[PE2][PD2]

(PE3) + borrow[PD3][ND3] => (ND3) + Y-boson[PE3][PD3]

Then [PE1][PD1] + [PE2][PD2] + [PE3][PD3] => W-plus

Example: Positive U-quark emits a W-plus.

$(PD1) + \text{borrow}[PE1][NE1] \Rightarrow (NE1) + Y\text{-boson}[PE1][PD1]$

$(PE2) + \text{borrow}[PD2][ND2] \Rightarrow (ND2) + Y\text{-boson}[PE2][PD2]$

$(PE3) + \text{borrow}[PD3][ND3] \Rightarrow (ND3) + Y\text{-boson}[PE3][PD3]$

Then  $[PE1][PD1] + [PE2][PD2] + [PE3][PD3] \Rightarrow W\text{-plus}$

#### 4. Weak pairs

Figure 9 shows the sixteen first-generation elementary fermions, with the particles of negative sign (bottom row) arranged in reverse order of flavour. Now, the two fermions in each vertical column constitute a **weak pair**.

When an elementary fermion emits or absorbs a W-boson of appropriate sign, it changes into its weak pair partner.

On emitting a W-boson, an elementary fermion changes (a) its preon composition, (b) its sign, and (c) its flavour. But note that a lepton remains a lepton (ie. singlet state), and a quark remains a quark (ie. non-singlet state).

A charged lepton changes into a neutral lepton, or vice versa.

eg. Positron  $\Rightarrow$  Electron antineutrino + W-plus.

A U-flavour quark changes into a D-flavour quark, or vice versa. Note that in the transition, the isomeric form does not change.

eg. PosU(A)  $\Rightarrow$  NegD(A) + W-plus.

ie.  $(PD1/PE2/PE3) \Rightarrow (NE1/ND2/ND3) + W\text{-plus}$ .

These two specific isomeric forms form a weak pair.

The two quarks forming a weak pair are of same isomeric form.

Thus, a specific isomeric form of one quark can change only into one of the three isomeric forms of the other quark.

#### 5. W-boson absorption

On absorbing a W-boson, an elementary fermion changes into its weak pair partner. Each constituent preon pairs up with its antipreon present in the W-boson. Three preon-antipreon pairs are thus formed, and return to the vacuum. The remaining three preons become the constituent preons of the new elementary fermion, which is now of opposite sign. Note that the returned preon-antipreon pairs need not be identical to the borrowed ones.

#### 6. Weak charged interactions

In a weak charged interaction, two elementary fermions of unlike sign exchange a W-boson between themselves. If the two fermions are the two members of a weak pair, they will exchange identity and attract each other.

However, the attractive force is too weak to bind them together.

Eg. Positron + Electron antineutrino  $\Rightarrow$  Electron antineutrino + Positron.

When two fermions of unlike sign that are not members of the same weak pair interact, both particles change flavour and sign (ie. each changes into its weak pair partner). But the two particles will not attract each other.

In practice, due to energy considerations, very few weak charged interactions can occur.

Quarks and leptons of higher generation can theoretically interact through the weak charged force just like those of the first generation. They form the corresponding weak pairs. Interactions between particles of different

generations are also possible. The negative muon and the muon neutrino can exchange a virtual W-boson, and exchange identity. But the second-generation negative muon can also interact with the third-generation tau neutrino.

## 7. Handedness

Any quark or charged lepton can be either left-handed or right-handed. But neutral leptons have one handedness only. The neutrino (of any generation) is left-handed; the antineutrino (of any generation) is right-handed. The preon model being discussed cannot explain why neutral leptons have one handedness only.

A weak charged interaction occurs only between two elementary fermions of unlike sign that are of same handedness. So, interactions involving a neutral lepton will perforce be skewed, because the neutral lepton has only one handedness state. For example, an electron and an electron neutrino can interact and change into each other. But the interaction only occurs if the electron is left-handed, ie. if it has the same handedness as the neutrino. The right-handed electron cannot interact with an electron neutrino, because the two fermions have different handedness.

## 8. W-boson decay

The W-boson decays by dividing its six preons into two packets of three preons each (Figure 10). Two elementary fermions of same sign are thus formed, most often of same generation. In a leptonic decay, the W-boson decays to a charged lepton plus a neutral lepton; in a hadronic decay, the products are two quarks of same isomeric form but of different flavour. The two quarks may remain associated to form a charged meson, or they may combine with a quark-antiquark pair from the vacuum to form two mesons (one charged and one neutral).

W-boson decay can produce all possible first and second generation decay products. But note that hadronic decay cannot produce the third generation meson containing a top and bottom quark bound together, as this would be too massive.

Note that when a W-boson decays in the leptonic mode, two leptons of opposite handedness are always produced.

$W^- \Rightarrow \text{electron(L)} + \text{antineutrino(R)}$

$W^+ \Rightarrow \text{positron(R)} + \text{neutrino(L)}$

## 9. W-boson reconstitution

Two quarks that can be produced in a hadronic decay of a W-boson can also 'combine' to reconstitute a virtual W-boson. The quarks do not actually combine; one of them emits a W-boson.

Example:  $\text{PosU(A)} + \text{PosD(A)} \Rightarrow \text{W-plus}$

$\text{PosU(A)} \Rightarrow \text{NegD(A)} + \text{W-plus}$

ie.  $(\text{PD1/PE2/PE3}) \Rightarrow (\text{NE1/ND2/ND3}) + \text{W-plus}$

the newly-formed NegD(A) pairs with the unchanged PosD(A)

then the quark-antiquark pair enters the vacuum

the result is a virtual W-boson.

The two leptons produced in a leptonic decay of a W-boson cannot combine to reconstitute a virtual W-boson. This is because leptons, being in the singlet state, do not get close enough for this process to occur.

**Figure 8 - W-Boson**

|     |     |
|-----|-----|
| PE1 | PD1 |
| PE2 | PD2 |
| PE3 | PD3 |

**W-Plus**

|     |     |
|-----|-----|
| NE1 | ND1 |
| NE2 | ND2 |
| NE3 | ND3 |

**W-Minus**

Figure 9 - Eight Weak Pairs

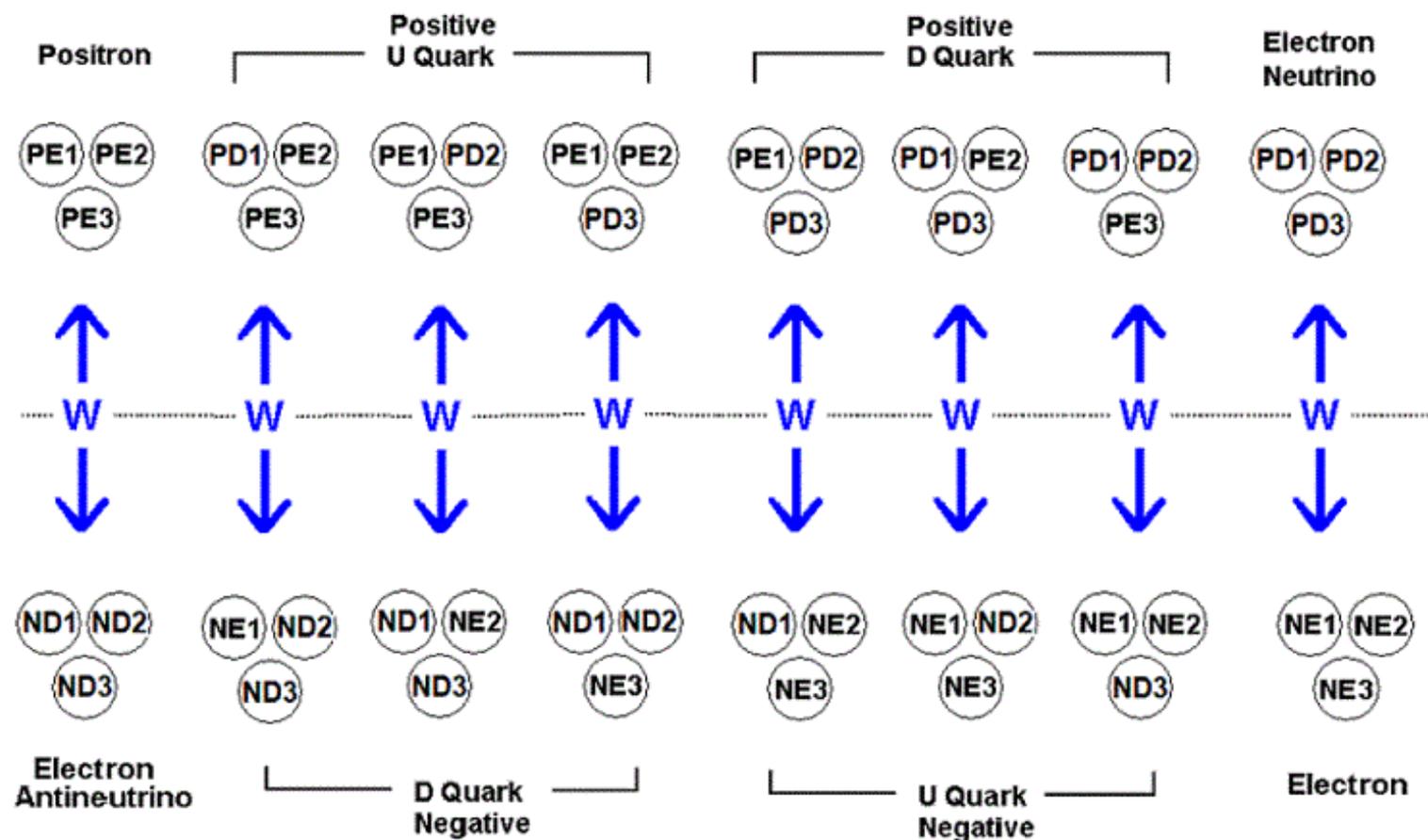
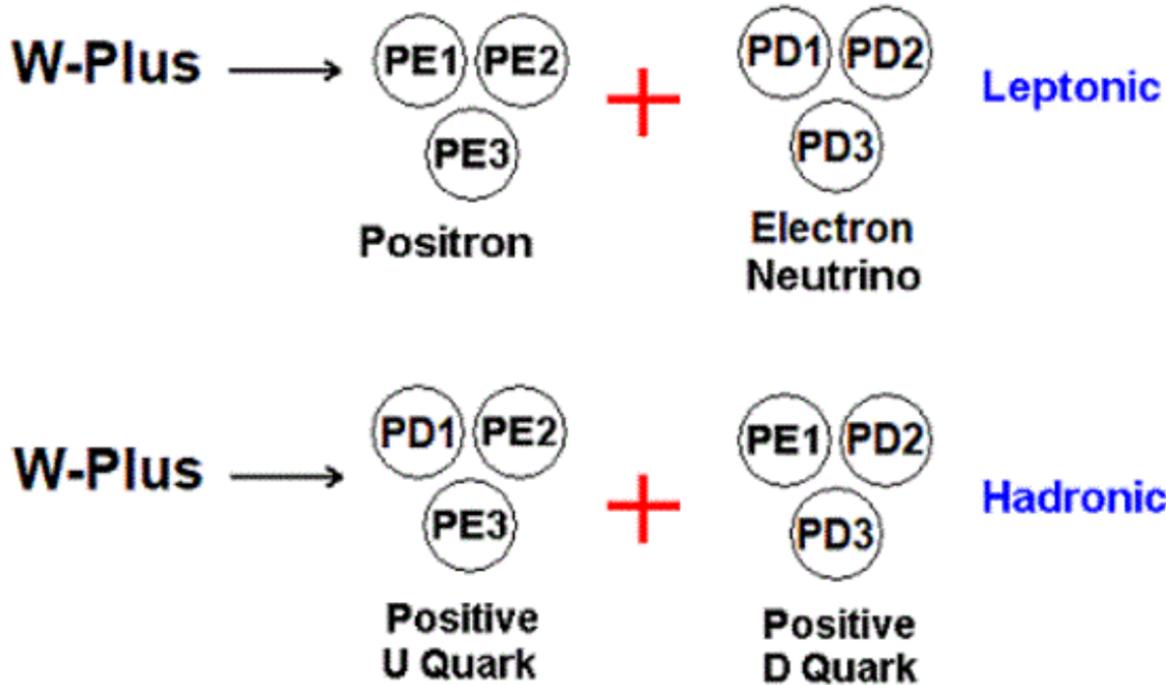


Figure 10 - Decay Of W-Plus Boson (Example)



# Weak Neutral Force

## 1. Introduction

The **weak neutral force** is a secondary force that acts between elementary fermions. It is transmitted by a massive boson called the **Z-boson**, which is composed of preons. This boson is in the singlet state. It can be created as a real particle in accelerator collisions, and can be observed (indirectly, through its decay products). Unlike the W-boson, it does not have an antiparticle.

mass = 80 GeV; spin = 1; electric charge = 0; range =  $10^{-16}$  cm; lifetime =  $10^{-25}$  s

The weak neutral force originates at the preon level. The Z-boson is generated when three gluons combine. It is thus composed of six different preons, which together constitute three different preon-antipreon pairs. Figure 11 (at end of article) shows an example of a Z-boson.

## 2. Z-boson emission

A Z-boson is generated when the three constituent preons change into each other at the same time. Each preon changes into one of the other two constituent preons, emitting a gluon. So, three different gluons are generated; these associate together to form a Z-boson. When a Z-boson is emitted, there is no net change in the preon composition of the elementary fermion (although each preon changes identity). To generate a Z-boson, three preon-antipreon pairs must be borrowed from the vacuum.

A Z-boson contains six different preons that formally correspond to three different preon-antipreon pairs. These pairs are the same as (a) the three borrowed vacuum pairs, and (b) the three constituent preons together with their antipreons. There are several different isomeric forms of the Z-boson, with different combinations of formal preon-antipreon pairs (all three electric, all three dipolar, or mixed). The Z-boson is in the singlet state.

Example: Positron emits a Z-boson.

(PE1) => (PE2) + gluon[PE1][NE2]

(PE2) => (PE3) + gluon[PE2][NE3]

(PE3) => (PE1) + gluon[PE3][NE1]

Then [PE1][NE2] + [PE2][NE3] + [PE3][NE1] => Z-boson

Example: Positive U-quark emits a Z-boson.

(PD1) => (PE2) + gluon[NE2][PD1]

(PE2) => (PE3) + gluon[PE2][NE3]

(PE3) => (PD1) + gluon[PE3][ND1]

Then [NE2][PD1] + [PE2][NE3] + [PE3][ND1] => Z-boson

## 3. Z-boson absorption

On absorbing a Z-boson, each gluon transfers some momentum to one of the three constituent preons. The three preon-antipreon pairs present in the boson are returned to the vacuum. The elementary fermion retains its preon composition.

## 4. Weak neutral interactions

In a weak neutral interaction, two elementary fermions (of like or of unlike sign) exchange a Z-boson between themselves. The two fermions retain their identity; they just scatter each other. The handedness of the fermion does not make any difference. The Z-boson couples equally to left-handed and right-handed fermions.

## 5. Z-boson decay

The Z-boson decays by dividing its six preons into two packets of three preons each, keeping together preons of like sign. A fermion-antifermion pair is thus formed. In a leptonic decay, the Z-boson decays to a lepton and its antilepton; any lepton-antilepton pair can be produced (eg. positron and electron). In a hadronic decay, the direct products are a quark and its antiquark (except top-antitop which are too heavy); these then combine with quark-antiquark pairs from the vacuum to form the observed particle jets.

**Figure 11 - Z-Boson (Example)**

|            |            |
|------------|------------|
| <b>PE1</b> | <b>NE1</b> |
| <b>PD2</b> | <b>ND2</b> |
| <b>PE3</b> | <b>NE3</b> |

## Some Weak Processes

### 1. Neutrino oscillation

This is a W-boson reabsorption process.

When a neutrino (positive sign) of any generation emits a virtual W-plus, it changes temporarily into its weak pair partner (negatively charged lepton). The W-plus is then promptly reabsorbed by the charged lepton, reconstituting the original neutrino. But very rarely this process will result in a neutrino of a different generation. This is possible because there is a vanishingly small mass difference between neutrinos of differing generation. Changes in velocity of the neutrino can supply the small amount of energy required to increase or decrease the mass of the particle.

Example: Electron neutrino becomes muon neutrino.

(a) W-boson emission:

electron neutrino(PD1/PD2/PD3) + borrow [PE1][NE1]+[PE2][NE2]+[PE3][NE3]  
gives => negative muon(NE1/NE2/NE3) + W-plus[PE1/PE2/PE3/PD1/PD2/PD3]

(b) W-boson reabsorption:

negative muon(NE1/NE2/NE3) + W-plus[PE1/PE2/PE3/PD1/PD2/PD3]  
gives => muon neutrino(PD1/PD2/PD3) + return[PE1][NE1]+[PE2][NE2]+[PE3][NE3]

Antineutrinos oscillate in exactly the same way. Charged leptons cannot oscillate, because there is a large mass difference between generations.

### 2. Electron-capture

This is a weak interaction between an orbital electron in an inner shell and a proton in a proton-rich nucleus. The electron emits a W-minus, thus changing into an electron neutrino. The W-minus is absorbed by a positive U-quark inside a proton, which thus changes into a negative D-quark. The proton is thus changed into a neutron.

electron => electron neutrino + W-minus.  
then Pos U-Quark + W-minus => Neg D-Quark.

### 3. Decay of a free neutron

A free neutron takes quite a long time (15 minutes) to decay, because of the very low mass difference between the neutron and its decay products. Decay can occur in two ways, both involving a weak decay.

(1) Weak charged force only:

a constituent D-quark changes into a U-quark;

so the neutron changes into a proton.

eg. NegD(A) => PosU(A) + W-minus

then W-minus => electron + electron antineutrino.

(2) Strong force plus weak charged force:

(a) The neutron emits a virtual pi-minus (strong force) and turns into a proton.

eg. NegD(A) quark changes into a PosU(A) quark

ie. NegD(A) + borrow[PosU(A)][NegU(A)] => PosU(A) + pi-minus[NegU(A)][NegD(A)]

(b) The emitted virtual pi-minus is usually reabsorbed, turning the proton back into a neutron.

ie. PosU(A) + pi-minus[NegU(A)][NegD(A)] => NegD(A) + return[PosU(A)][NegU(A)]

(c) Rarely the virtual pi-minus decays (weak force) to real particles instead of being reabsorbed.

ie. virtual pi-minus[NegU(A)][NegD(A)] => virtual W-minus  
then W-minus => electron + electron antineutrino.

#### 4. Beta decay

In radioactive elements, a neutron inside a nucleus will occasionally spontaneously convert into a proton, thus resulting in a more stable nucleus. The decay mechanism is the same as that of a free neutron.

In beta plus decay, a proton inside a nucleus spontaneously converts into a neutron, with the emission of a positron and an electron neutrino. The actual reaction is:

Pos U-quark => Neg D-quark + W-plus

An isolated proton cannot convert into a neutron. But inside a nucleus, the energy necessary to drive this decay 'uphill' can sometimes be obtained if a more stable nucleus results from the decay.

#### 5. Experimental conversion

A neutron in a stable nucleus can also be forced to convert into a proton. The experiment consists in bombarding a target made of a stable element (eg. deuterium) with a beam of electron neutrinos. Occasionally, a weak interaction will occur between one of the neutron's negative D-quarks and the incoming neutrino. The two elementary fermions will exchange a virtual W-boson. A deuterium nucleus will be changed into two free protons.

The reaction is:

Neg D-quark + Electron neutrino => Pos U-quark + Electron

#### 6. Muon decay

A negative muon decays almost always to a muon neutrino (its weak pair partner), plus an electron and an electron antineutrino.

Neg Muon => Muon neutrino + W-minus  
then W-minus => Electron + Electron antineutrino

Extremely rarely, the negative muon decays through the weak neutral force by emitting a Z-boson.

Neg Muon => Electron + Z-boson  
then Z-boson => Electron + Positron, or two photons

#### 7. Change of generation

Higher-generation quarks and leptons decay into fermions of lower generation mainly through the weak charged force (ie. by emitting a W-boson). This causes them to change sign. Decay through the weak neutral force (ie. by emitting a Z-boson) is also possible, but is much rarer.

Usual decay: Neg S-quark => Pos U-quark + W-minus.

Very rare decay: Neg S-quark => Neg D-quark + Z-boson.

# Baryons

## 1. Building baryons

Quarks are not in the singlet state; so they aggregate together spontaneously to form particles (baryons) that are in the singlet state. Baryons are observable in isolation.

Baryon construction rules:

- (1) One quark of each of the three isomeric forms A, B, C.
- (2) Quarks of same electric charge magnitude must be of same sign.
- (3) Quarks of differing electric charge magnitude must be of unlike sign.

The above rules ensure that all baryons will be in the singlet state.

Two quarks that can be found together in at least one baryon are compatible with each other.

Using the first-generation quarks, we can construct sixteen different baryons, each with a unique quark composition. Figure 12 (at end of article) shows their general structure. Note that they can be grouped into two families (top and bottom rows), based on their quark composition.

Each family contains eight baryons. The nucleon family (top row) is built from positive U-quarks and negative D-quarks. The baryons composed of two types of quark (proton and neutron) come in three isomeric forms (not shown in table). The antinucleon family (bottom row) is built from negative U-quarks and positive D-quarks. The baryons in one family are the antiparticles of the baryons in the other family.

## 2. Strong pairs

A U-quark and a D-quark of unlike sign but of same isomeric form constitute a **strong pair**. Only one member of such a pair can be found inside a baryon.

There are six strong pairs:

- Positive U-quark(A) and Negative D-quark(A)
- Positive U-quark(B) and Negative D-quark(B)
- Positive U-quark(C) and Negative D-quark(C)
- Negative U-quark(A) and Positive D-quark(A).
- Negative U-quark(B) and Positive D-quark(B).
- Negative U-quark(C) and Positive D-quark(C).

Note: A strong pair is composed of the same two quarks that also form a weak pair.

## 3. Delta baryons

The delta plus plus is composed of the three different positive U-quarks; the delta minus is composed of the three different negative D-quarks.

| Delta Plus Plus |             |    |    |    |
|-----------------|-------------|----|----|----|
| Quarks          | Preons      | E1 | E2 | E3 |
| PosU(A)         | PD1/PE2/PE3 | +1 | 0  | +1 |

|                |                    |           |           |           |
|----------------|--------------------|-----------|-----------|-----------|
| <b>PosU(B)</b> | <b>PE1/PD2/PE3</b> | <b>+1</b> | <b>+1</b> | <b>0</b>  |
| <b>PosU(C)</b> | <b>PE1/PE2/PD3</b> | <b>0</b>  | <b>+1</b> | <b>+1</b> |
|                |                    | <b>+2</b> | <b>+2</b> | <b>+2</b> |

| <b>Delta Minus</b> |                    |           |           |           |
|--------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>      | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>NegD(A)</b>     | <b>NE1/ND2/ND3</b> | <b>0</b>  | <b>-1</b> | <b>0</b>  |
| <b>NegD(B)</b>     | <b>ND1/NE2/ND3</b> | <b>0</b>  | <b>0</b>  | <b>-1</b> |
| <b>NegD(C)</b>     | <b>ND1/ND2/NE3</b> | <b>-1</b> | <b>0</b>  | <b>0</b>  |
|                    |                    | <b>-1</b> | <b>-1</b> | <b>-1</b> |

#### 4. Proton

The proton is composed of two different positive U-quarks and one negative D-quark. It comes in three different isomeric forms, which differ in quark isomer composition and preon composition.

Note: The isomeric form of a proton is labelled A, B, or C depending on the isomeric form of the single D-quark it contains.

| <b>Proton (A)</b> |                    |           |           |           |
|-------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>     | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>NegD(A)</b>    | <b>NE1/ND2/ND3</b> | <b>0</b>  | <b>-1</b> | <b>0</b>  |
| <b>PosU(B)</b>    | <b>PE1/PD2/PE3</b> | <b>+1</b> | <b>+1</b> | <b>0</b>  |
| <b>PosU(C)</b>    | <b>PE1/PE2/PD3</b> | <b>0</b>  | <b>+1</b> | <b>+1</b> |
|                   |                    | <b>+1</b> | <b>+1</b> | <b>+1</b> |

| <b>Proton (B)</b> |                    |           |           |           |
|-------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>     | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosU(A)</b>    | <b>PD1/PE2/PE3</b> | <b>+1</b> | <b>0</b>  | <b>+1</b> |
| <b>NegD(B)</b>    | <b>ND1/NE2/ND3</b> | <b>0</b>  | <b>0</b>  | <b>-1</b> |
|                   |                    |           |           |           |

|                |                    |           |           |           |
|----------------|--------------------|-----------|-----------|-----------|
| <b>PosU(C)</b> | <b>PE1/PE2/PD3</b> | <b>0</b>  | <b>+1</b> | <b>+1</b> |
|                |                    | <b>+1</b> | <b>+1</b> | <b>+1</b> |

| <b>Proton (C)</b> |                    |           |           |           |
|-------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>     | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosU(A)</b>    | <b>PD1/PE2/PE3</b> | <b>+1</b> | <b>0</b>  | <b>+1</b> |
| <b>PosU(B)</b>    | <b>PE1/PD2/PE3</b> | <b>+1</b> | <b>+1</b> | <b>0</b>  |
| <b>NegD(C)</b>    | <b>ND1/ND2/NE3</b> | <b>-1</b> | <b>0</b>  | <b>0</b>  |
|                   |                    | <b>+1</b> | <b>+1</b> | <b>+1</b> |

## 5. Neutron

The neutron is composed of one positive U-quark and two different negative D-quarks. It comes in three different isomeric forms, which differ in quark isomer composition and preon composition.

Note: The isomeric form of a neutron is labelled A, B, or C depending on the isomeric form of the single U-quark it contains.

| <b>Neutron (A)</b> |                    |           |           |           |
|--------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>      | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosU(A)</b>     | <b>PD1/PE2/PE3</b> | <b>+1</b> | <b>0</b>  | <b>+1</b> |
| <b>NegD(B)</b>     | <b>ND1/NE2/ND3</b> | <b>0</b>  | <b>0</b>  | <b>-1</b> |
| <b>NegD(C)</b>     | <b>ND1/ND2/NE3</b> | <b>-1</b> | <b>0</b>  | <b>0</b>  |
|                    |                    | <b>0</b>  | <b>0</b>  | <b>0</b>  |

| <b>Neutron (B)</b> |                    |           |           |           |
|--------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>      | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>NegD(A)</b>     | <b>NE1/ND2/ND3</b> | <b>0</b>  | <b>-1</b> | <b>0</b>  |
| <b>PosU(B)</b>     | <b>PE1/PD2/PE3</b> | <b>+1</b> | <b>+1</b> | <b>0</b>  |
| <b>NegD(C)</b>     | <b>ND1/ND2/NE3</b> | <b>-1</b> | <b>0</b>  | <b>0</b>  |

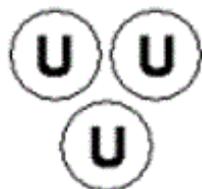
|  |  |          |          |          |
|--|--|----------|----------|----------|
|  |  | <b>0</b> | <b>0</b> | <b>0</b> |
|--|--|----------|----------|----------|

|                    |  |  |  |  |
|--------------------|--|--|--|--|
| <b>Neutron (C)</b> |  |  |  |  |
|--------------------|--|--|--|--|

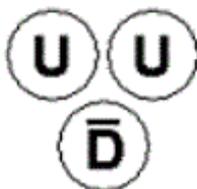
| <b>Quarks</b>  | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
|----------------|--------------------|-----------|-----------|-----------|
| <b>NegD(A)</b> | <b>NE1/ND2/ND3</b> | <b>0</b>  | <b>-1</b> | <b>0</b>  |
| <b>NegD(B)</b> | <b>ND1/NE2/ND3</b> | <b>0</b>  | <b>0</b>  | <b>-1</b> |
| <b>PosU(C)</b> | <b>PE1/PE2/PD3</b> | <b>0</b>  | <b>+1</b> | <b>+1</b> |
|                |                    | <b>0</b>  | <b>0</b>  | <b>0</b>  |

**Figure 12 - Baryon Structure**

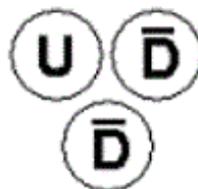
**Delta plus plus**



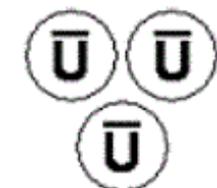
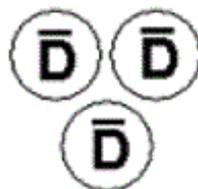
**Proton**



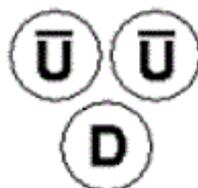
**Neutron**



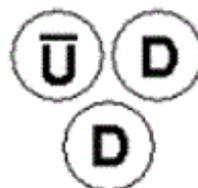
**Delta minus**



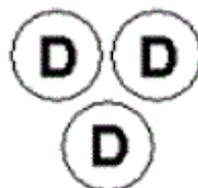
**Delta minus minus**



**Antiproton**



**Antineutron**



**Delta plus**

[U or D = positive quark; U-bar or D-bar = negative quark]

# How Quarks Bind Together

## 1. Introduction

The three constituent quarks that make up a baryon are bound together by a short-range secondary force called the **quark-binding force**. It is transmitted by several virtual **mesons** of moderate mass, with a range of about 1 fermi. The quark-binding force is quite powerful, and keeps the constituent quarks permanently confined within the baryon.

## 2. Quark interactions

In a quark interaction, a constituent quark emits a meson and a second constituent quark absorbs it. As a result, the two quarks exchange identity, and the quark-binding force acts between them. The two quarks thus attract each other. Incessant interactions, two quarks at a time involving all three constituent quarks, keep the quarks tightly bound together to form a discrete particle.

Let's examine how two positive U-quarks of different isomeric form interact inside a delta plus plus baryon. The three different isomers are labelled A, B, and C. See Figure 13 at end of article.

The quark interaction occurs through the vacuum shuttle mechanism. But now, a quark-antiquark pair must be borrowed from the vacuum.

See Figure 14 (Meson Emission).

See Figure 15 (Meson Absorption).

The above interaction can be written as:

$$\text{PosU(A) at X} + \text{borrow}[\text{PosU(B)}][\text{NegU(B)}] \Rightarrow \text{PosU(B) at X} + \text{meson}[\text{PosU(A)}][\text{NegU(B)}]$$

$$\text{PosU(B) at Y} + \text{meson}[\text{PosU(A)}][\text{NegU(B)}] \Rightarrow \text{PosU(A) at Y} + \text{return}[\text{PosU(B)}][\text{NegU(B)}]$$

In preon terms:

$$(\text{PD1/PE2/PE3}) \text{ at X} + \text{borrow}[\text{PE1/PD2/PE3}][\text{NE1/ND2/NE3}] \Rightarrow (\text{PE1/PD2/PE3}) \text{ at X} + \text{meson}[\text{PD1/PE2/PE3}][\text{NE1/ND2/NE3}]$$

$$(\text{PE1/PD2/PE3}) \text{ at Y} + \text{meson}[\text{PD1/PE2/PE3}][\text{NE1/ND2/NE3}] \Rightarrow (\text{PD1/PE2/PE3}) \text{ at Y} + \text{return}[\text{PE1/PD2/PE3}][\text{NE1/ND2/NE3}]$$

The two constituent quarks left at the end of the interaction are not the same two that entered it. One constituent quark has been moved, while the other has disappeared into the vacuum. A virtual quark (identical to the disappeared quark) has been 'promoted' from the vacuum to become a constituent quark. So the composition of the baryon does not change.

All quark interactions follow this general pattern.

## 3. Mesons

The mesons that bind quarks together inside baryons are not in the singlet state. Hence, such mesons are unobservable, and exist only temporarily in virtual form. All such mesons consist of two quarks.

All possible interactions between non-identical U-quarks of same sign are mediated by a set of six neutral mesons. Each is composed of two U-quarks of unlike sign and of different isomeric form (ie. they are not a quark-antiquark pair).

| <b>A Neutral Meson (U-U)</b> |                    |           |           |           |
|------------------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>                | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosU(A)</b>               | <b>PD1/PE2/PE3</b> | <b>+1</b> | <b>0</b>  | <b>+1</b> |
| <b>NegU(B)</b>               | <b>NE1/ND2/NE3</b> | <b>-1</b> | <b>-1</b> | <b>0</b>  |
|                              |                    | <b>0</b>  | <b>-1</b> | <b>+1</b> |

All possible interactions between non-identical D-quarks of same sign are mediated by a separate set of six different neutral mesons. Each is composed of two D-quarks of unlike sign and of different isomeric form (ie. they are not a quark-antiquark pair).

| <b>A Neutral Meson (D-D)</b> |                    |           |           |           |
|------------------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>                | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosD(B)</b>               | <b>PD1/PE2/PD3</b> | <b>0</b>  | <b>0</b>  | <b>+1</b> |
| <b>NegD(C)</b>               | <b>ND1/ND2/NE3</b> | <b>-1</b> | <b>0</b>  | <b>0</b>  |
|                              |                    | <b>-1</b> | <b>0</b>  | <b>+1</b> |

All possible interactions between a U-quark and a D-quark of unlike sign are mediated by twelve different charged mesons. Six have a positive and six have a negative electric charge. Each is composed of a U-quark and a D-quark of same sign and of different isomeric form (ie. charged meson is non-singlet).

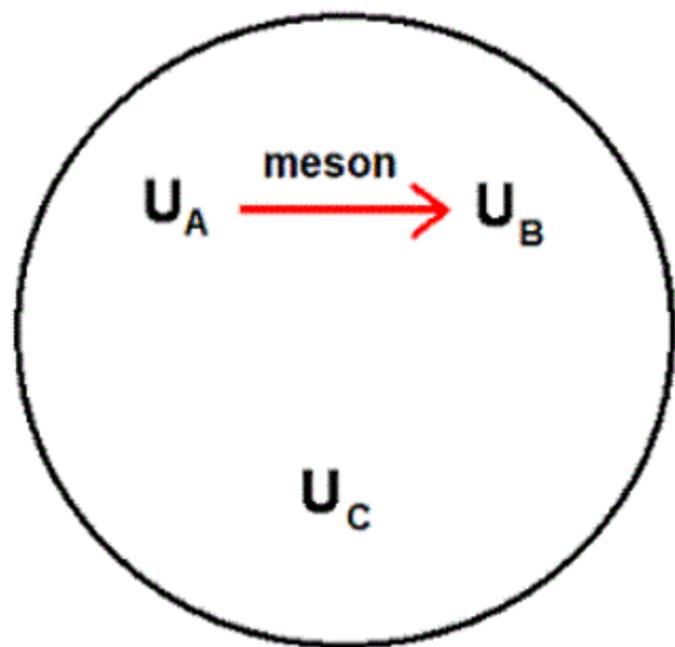
| <b>A Charged Meson</b> |                    |           |           |           |
|------------------------|--------------------|-----------|-----------|-----------|
| <b>Quarks</b>          | <b>Preons</b>      | <b>E1</b> | <b>E2</b> | <b>E3</b> |
| <b>PosU(A)</b>         | <b>PD1/PE2/PE3</b> | <b>+1</b> | <b>0</b>  | <b>+1</b> |
| <b>PosD(B)</b>         | <b>PD1/PE2/PD3</b> | <b>0</b>  | <b>0</b>  | <b>+1</b> |
|                        |                    | <b>+1</b> | <b>0</b>  | <b>+2</b> |

Note: If there is a higher-generation quark in a baryon, the mesons that bind the three quarks together will vary accordingly. If there is a strange quark, a charged kaon will be necessary to bind this quark with a U-quark, and a neutral kaon to bind it with a D-quark. The mesons are generated as usual through the vacuum shuttle.

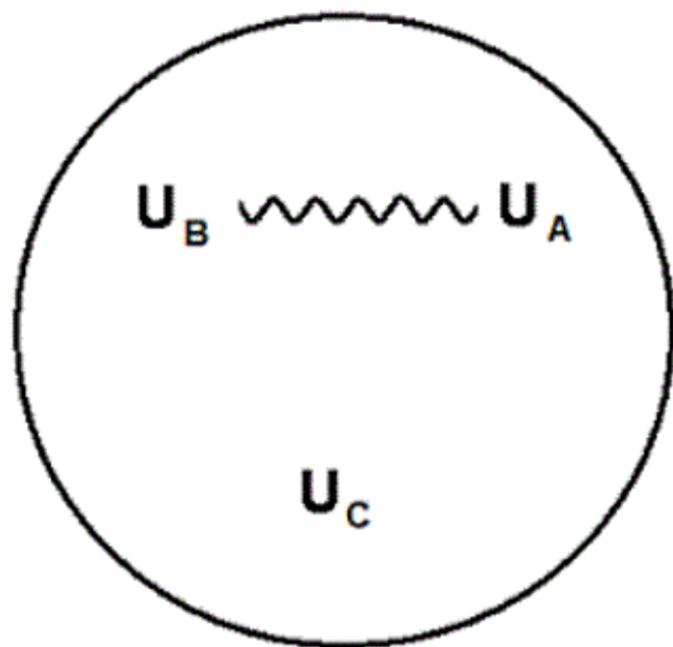
#### **4. Reabsorption**

All the mesons emitted by a constituent quark that cannot be absorbed by another constituent quark inside that baryon must be reabsorbed, ie. absorbed by the quark left behind at the emission site. No net change occurs.

Figure 13 - Two Quarks Interact Within A Delta Baryon



meson exchange



quarks exchange identity

Figure 14 - Meson Emission

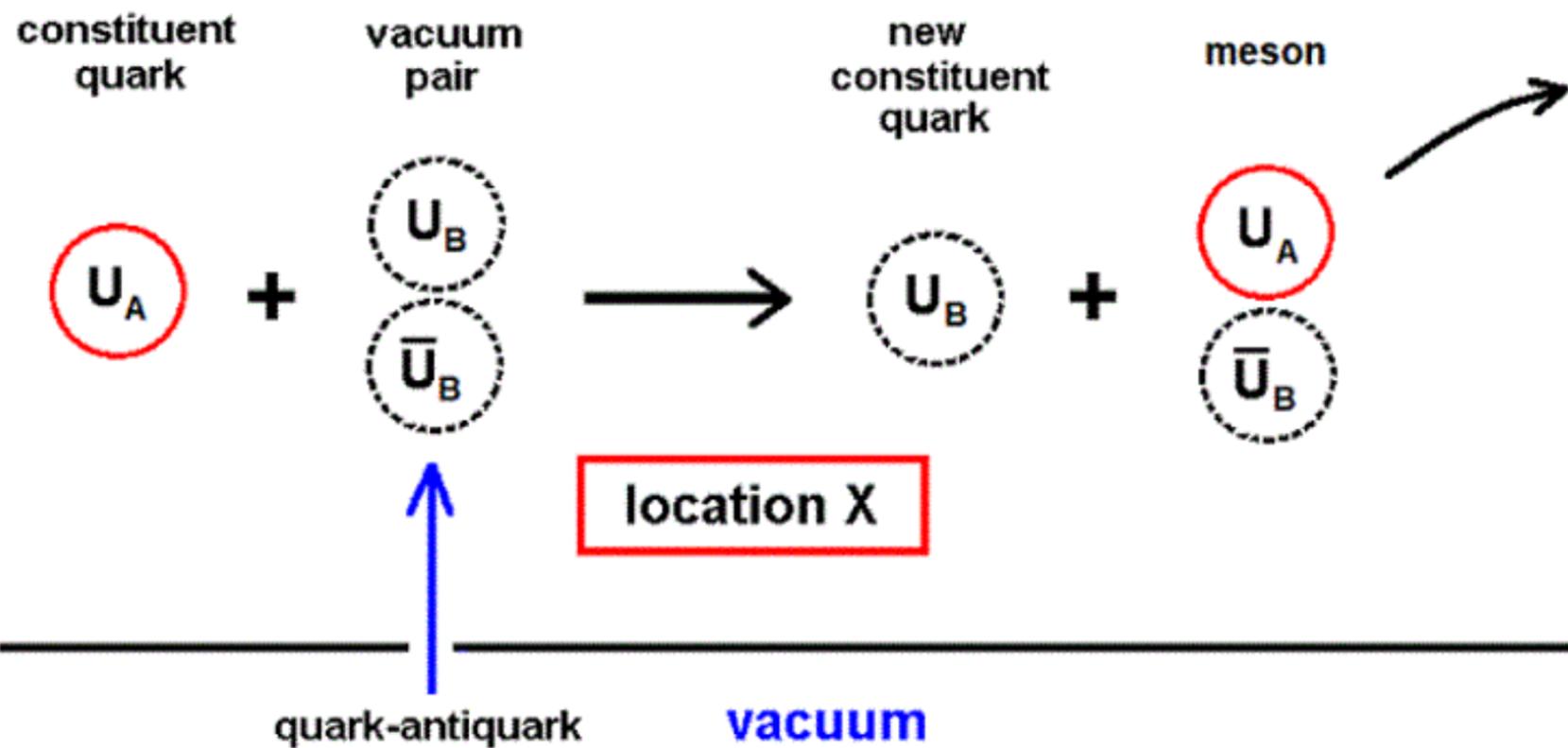
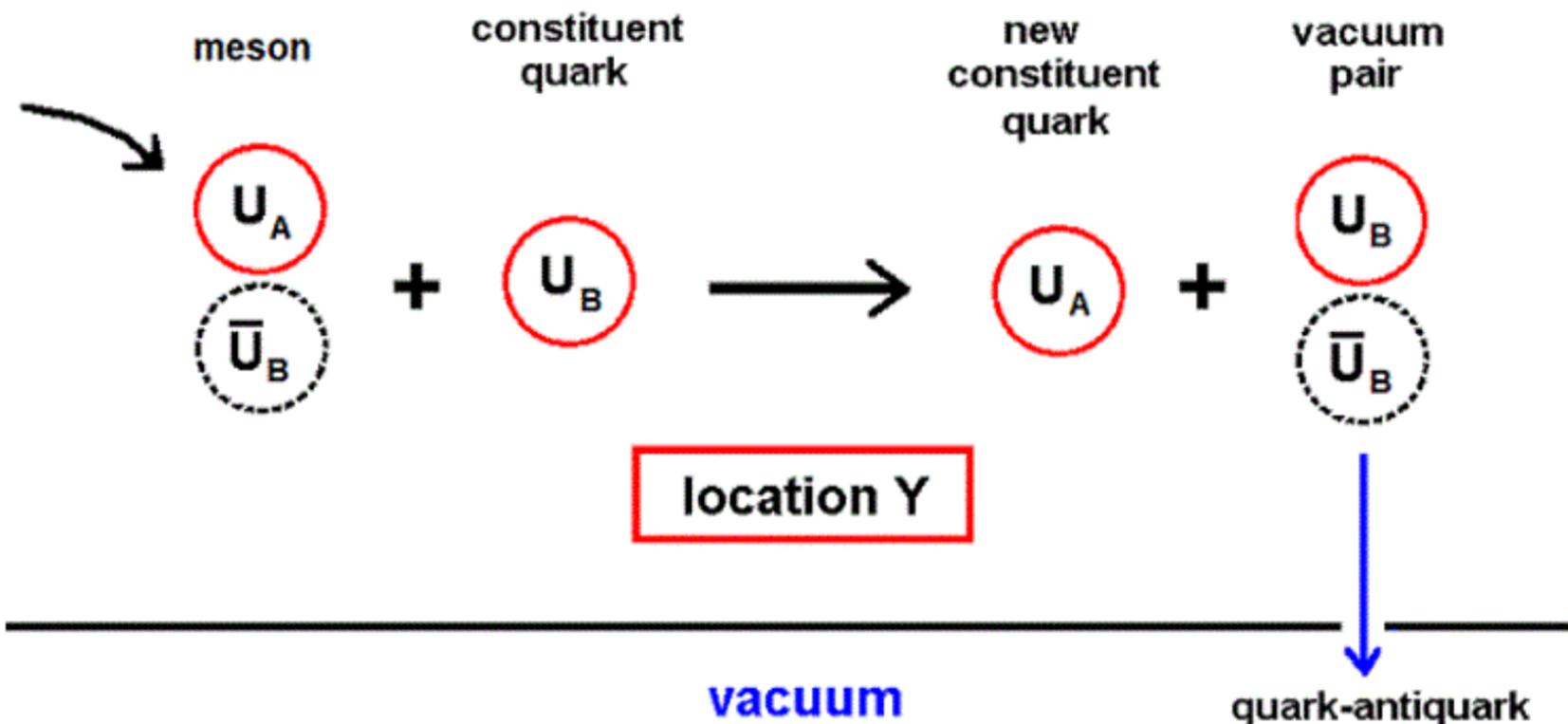


Figure 15 - Meson Absorption



# Strong Force

## 1. Introduction

Baryons are in the singlet state, and do not aggregate together spontaneously. They can be observed as isolated particles. But protons and neutrons are found bound together inside atomic nuclei. How does this happen? Obviously, there is a force binding them together.

Theoretically, if we remove a constituent quark from a baryon we can replace it only with a quark of same isomeric form. Either we replace it with a quark identical to it (with no net change), or we replace it with its strong-pair partner.

So, if the two members of a strong pair were located in two separate baryons, we could swap one member for the other. Both baryons would suffer a change in quark composition, and a change in net electric charge. Such an interaction could theoretically be effected through exchange of a massive boson called the **charged pion** (in singlet form). Boson exchange would give rise to a short-range secondary force called the **strong force**. Baryons are observed to be affected by this force, but in fact it is their constituent quarks that generate the force and respond to it.

Since a baryon is stable only if it is in the singlet state, any change in the quark composition of a baryon must preserve the singlet state.

Note: Higher generation forms of U and D quarks follow this scheme.

## 2. Strong interactions

In a **strong interaction**, a baryon emits a charged pion in singlet form and a second baryon absorbs it. The two baryons must form part of the same baryon family. Such baryons always share at least one strong pair. Two baryons forming part of different families cannot interact with each other, because they do not share any strong pair. Upon exchanging a charged pion, both baryons undergo a change in quark composition, but each remains in the singlet state.

Figure 16 (at end of article) shows that theoretically a delta plus plus baryon can interact with a neutron, resulting in the formation of two protons. The two quarks (one in each baryon) that exchange the charged pion attract each other. In consequence, the two baryons also attract each other. In the next article we examine how two nucleons can be bound together by the strong force. For this to occur, the two nucleons must change into each other when they interact.

The required charged pion (singlet) is generated through the usual vacuum shuttle mechanism by borrowing a quark-antiquark pair.

See Figure 17 (Emission Of Charged Pion).

See Figure 18 (Absorption Of Charged Pion).

The borrowed quark-antiquark pair must be returned to the vacuum as the interaction goes to completion.

## 3. Charged pions

The charged pion that transmits the strong force between baryons is in the singlet state. It is composed of two quarks of same sign and same isomeric form, but that differ in charge magnitude (flavour). There are thus six different charged pions (three positive and three negative). If created as real particles, they can be observed.

| A Positive Charged Pion |    |    |    |
|-------------------------|----|----|----|
|                         | E1 | E2 | E3 |
| PosU(A)                 | +1 | 0  | +1 |
| PosD(A)                 | 0  | +1 | 0  |
|                         | +1 | +1 | +1 |

mass=140 MeV; spin=0; range= $10^{-13}$  cm; lifetime= $10^{-8}$  s.

Note: In strong interactions between baryons containing higher-generation quarks, the meson that is exchanged will vary accordingly.

#### 4. Strong decay

A **strong decay** occurs when a baryon emits a real charged pion in singlet form, thus changing its quark composition. Such a decay therefore occurs through the strong force. The emitted charged meson can be detected directly, and it can also be detected by its decay products when it decays through the weak charged force. Heavy mesons (in singlet form) can also undergo strong decay.

#### 5. Delta baryons

There are eight delta baryons (mass=1232 MeV, spin=3/2) with an extremely short lifetime ( $10^{-23}$  s).

We previously mentioned four delta baryons, each of which is composed of the three different isomeric forms of the same quark; the quark is the positive U-quark, negative U-quark, positive D-quark, or negative D-quark. These four deltas are in the ground state. Orbital angular momentum is zero, and the intrinsic spins of the three quarks are aligned for a total spin of 3/2. These deltas decay exclusively by strong decay, ie. through the strong force. They emit a real charged pion (singlet), and change into a nucleon.

eg. Delta-plus-plus => Proton + Pi-plus

A quark-antiquark pair is borrowed, but a real charged pion (singlet form) is emitted.

PosU + borrow[PosD][NegD] => NegD + real pi-plus[PosU][PosD]

There are also four other delta baryons that have the same quark composition as the proton, neutron, antiproton, and antineutron. In these deltas, the three constituent quarks do not have aligned spins, so the net intrinsic spin is 1/2. But they have one unit of orbital angular momentum, so the total angular momentum is 3/2. These 'excited' delta baryons decay mostly through the strong force by emission of a real charged pion, changing their quark composition and their net electric charge. But occasionally they can decay by emission of a real photon (ie. electromagnetic decay) with no change in quark composition. In this case the orbital angular momentum is lost by radiating a photon, but the net electric charge of the baryon does not change.

eg. Delta-plus => Proton + photon  
(no change in quark composition).

#### 6. How nuclei are formed

Nucleons do not aggregate together spontaneously. They can be forced to do so inside stellar cores, where there are very high temperatures, pressures, and densities. Protons are squeezed close together, and strong interactions can now occur much more easily. To build nuclei, the first step is to convert protons into neutrons by the weak force. The neutrons that form immediately bind to other protons through the strong force to form deuterium.

Strong interactions between a proton and a neutron can now occur at a much higher rate, binding the two nucleons together. Other protons and neutrons can be added through other nucleosynthetic processes to give more complex nuclei. Eventually nuclei will be ejected, and will be found in low-energy environments like Earth. Once they are synthesized inside stars, most nuclei are stable even when transferred to a low-energy environment, but some are unstable (radioactive).

Figure 16 - A Strong Interaction

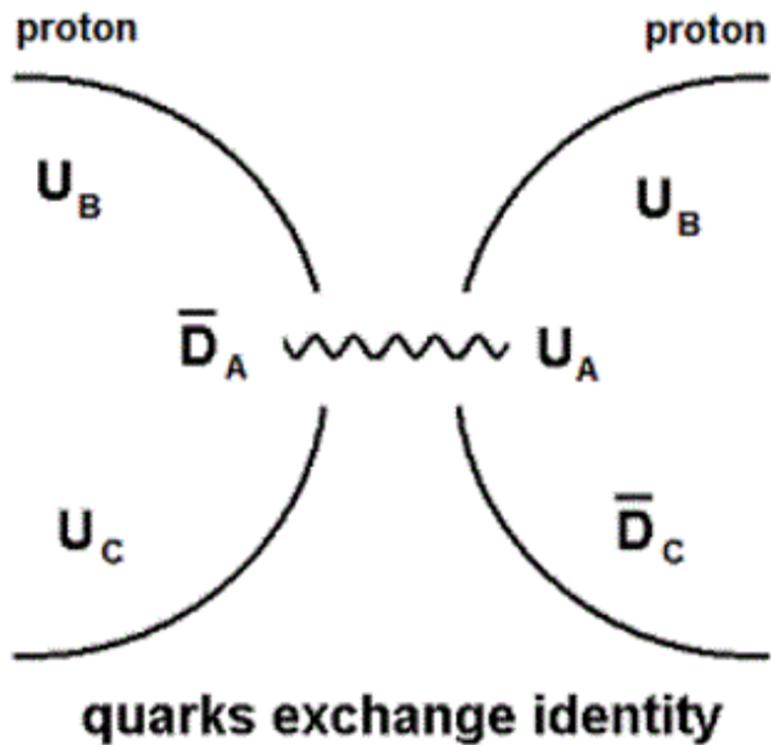
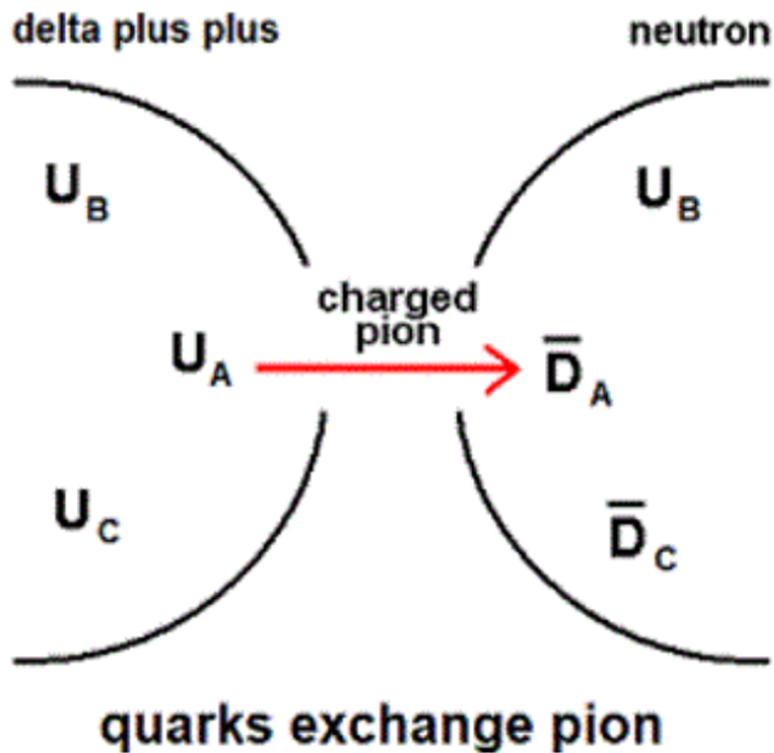
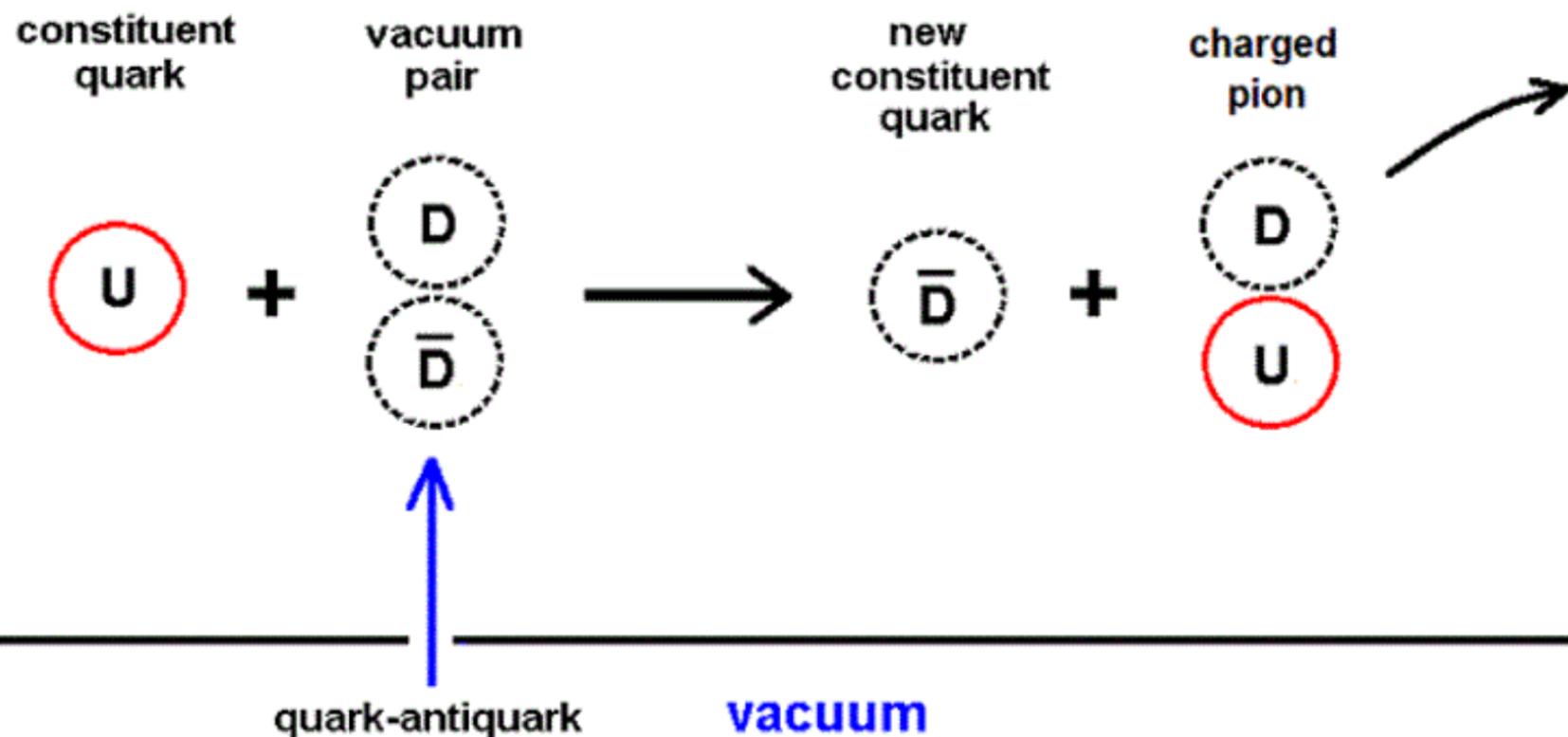
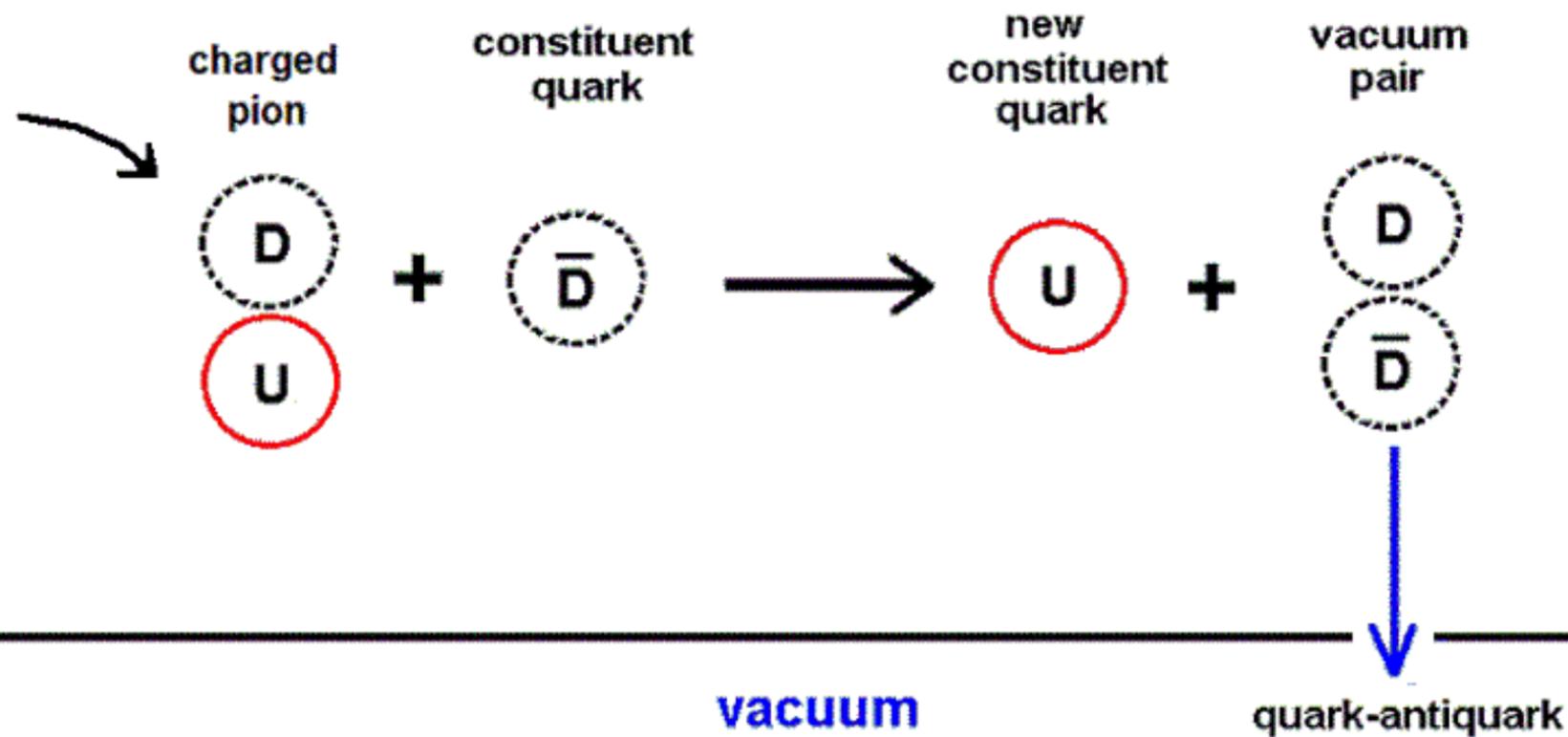


Figure 17 - Emission Of Charged Pion



**Figure 18 - Absorption Of Charged Pion**



# How Nucleons Bind Together

## 1. Introduction

Protons and neutrons are bound together by the strong force. Two nucleons interact by exchanging a virtual charged pion in singlet form. As we saw, the charged pion is emitted and absorbed by individual quarks within the nucleons. Once bound together by the strong force, nucleons can form stable atomic nuclei. Nucleons are bound together less strongly than are quarks inside baryons or preons inside elementary fermions; binding energy is relatively low.

## 2. Isomeric forms

Recall that both the proton and the neutron come in three different isomeric forms.

Any two non-identical nucleons will share at least one strong pair between them. One quark will be located in one nucleon, and its partner quark will be located in the other nucleon. This applies even if the two nucleons are two different isomeric forms of the proton, or of the neutron.

The strong force can easily bind together any isomer of a proton with any isomer of a neutron. But two different isomers of the proton, or two of the neutron, cannot be bound together.

## 3. Proton with neutron

A proton and a neutron share either one or three strong pairs (depending on the isomeric form of the two nucleons). Any one pair interacts by exchanging a charged pion (see Figure 19 at end of article). Frequent quark interactions results in a very strong bond between the proton and the neutron. Any one of the three isomeric forms of the proton can interact with any one of the three isomeric forms of the neutron.

A proton and a neutron can together form a stable nucleus (deuterium). In nuclei, the proton-neutron bond is the main structural agent that holds the nucleons together.

When the two quarks of a strong pair (one in the proton and one in the neutron) interact, they exchange identity and attract each other. Consequently, the two nucleons also attract each other. The quark interaction also causes the two nucleons to change into each other. Quark interactions occur at a high rate. So, the two nucleons keep changing into each other, and are bound tightly together. If there are three shared strong pairs, interactions will occur at a much higher rate, resulting in a stronger nuclear bond. Both interacting nucleons suffer a change in quark composition, and a change in nucleon type. Both nucleons remain in the singlet state.

The required charged pion is generated by the usual vacuum shuttle mechanism, by borrowing a quark-antiquark pair.

## 4. Proton with proton

Theoretically, two protons can interact, but only if they are of different isomeric form. Two identical protons (ie. same isomeric form, same quark composition) cannot interact.

### Non-identical protons

Any two non-identical protons share between them two different strong pairs, ie. each proton carries one member of each of the two strong pairs. For the two protons to exchange identity, both strong pairs must interact at the same time; each quark interaction is mediated by a charged pion in singlet form. So, two charged pions must be

exchanged between the interacting protons at the same time. The probability of this process is very low. See Figure 20.

Note: Exchange of only one charged pion would result in a delta plus plus and a neutron. As the products are of higher mass than the reactants, this reaction cannot occur.

For each strong pair, the usual vacuum shuttle mechanism is used to generate the charged pion inside one proton; this is then exchanged with the other member of the strong pair located in the other proton.

The interacting quarks, as usual, exchange identity and attract each other. Both interacting protons suffer a change in quark composition and in isomeric form. The two protons change into each other, including exchanging their isomeric form. But strong interactions occur at such a low rate that binding cannot occur. Two protons cannot form a stable nucleus.

### Identical protons

Two identical protons do not interact at all; consequently they do not attract each other. The reason is that there isn't a strong pair whose members are located one in each of the two protons. Therefore, any pion (charged or neutral, in singlet or non-singlet state) generated within one proton will be 'processed' inside that same proton - it will either be reabsorbed by the emitting quark, or it will be absorbed by another quark inside that same proton. Charged pion exchange between two identical protons cannot occur, as it would result in baryons that are not in the singlet state.

## **5. Neutron with neutron**

Theoretically, two neutrons interact exactly like two protons; only different isomeric forms can interact.

(a) Two non-identical neutrons share between them two different strong pairs. So they interact exactly like two non-identical protons. Two simultaneous quark interactions (each between a positive U-quark in one neutron, and a negative D-quark in the other neutron) occur through exchange of two charged pions in the singlet state. The two neutrons thus change into each other, but at extremely low rates. Two neutrons cannot bind together.

(b) Two identical neutrons cannot interact, as they do not share a strong pair. Charged pion exchange between them cannot occur. So they do not attract each other.

## **6. Conclusion**

In my opinion, the nucleons in a nucleus are bound together exclusively by the proton-neutron bond. Proton-proton bonds and neutron-neutron bonds do not exist.

## **7. Notes on nuclei**

A nucleon is specified by listing its quarks in order of their isomeric form A, B, C from left to right. The isomeric form of the nucleon itself is the same as the isomeric form of the minority quark.

Example:  $uud = \text{PosU}(A) + \text{PosU}(B) + \text{NegD}(C) = \text{proton}(C)$ .

A nuclide is a nucleus with a specified number of protons and a specified number of neutrons.

Z = number of protons.

N = number of neutrons.

A = number of nucleons (protons plus neutrons).

A proton and a neutron bound together by the strong force is referred to as a **p-n pair**. It is important to note whether the two nucleons are of same or of different isomeric form.

In all nuclei except those of hydrogen, there is a balance between two forces that have opposite effects:

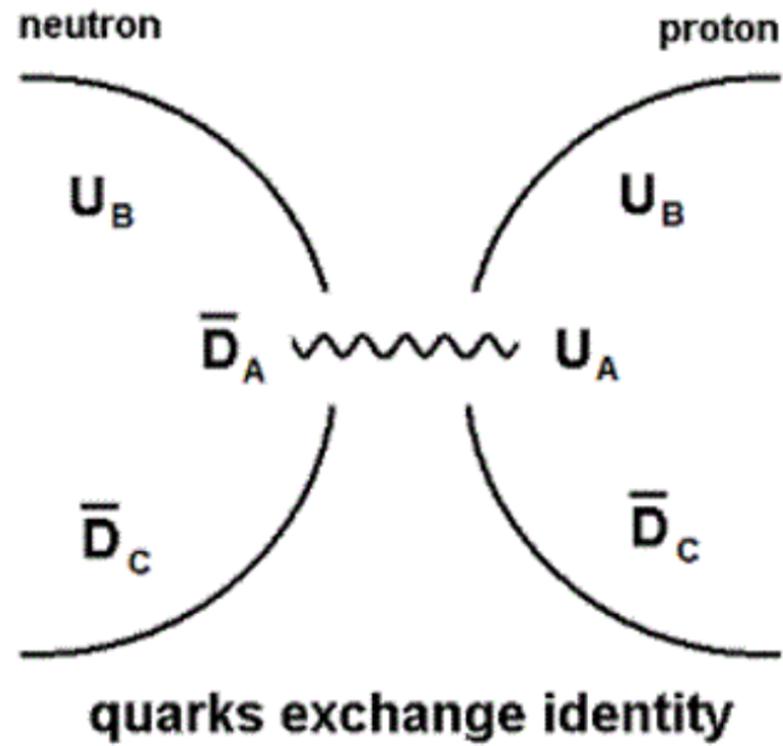
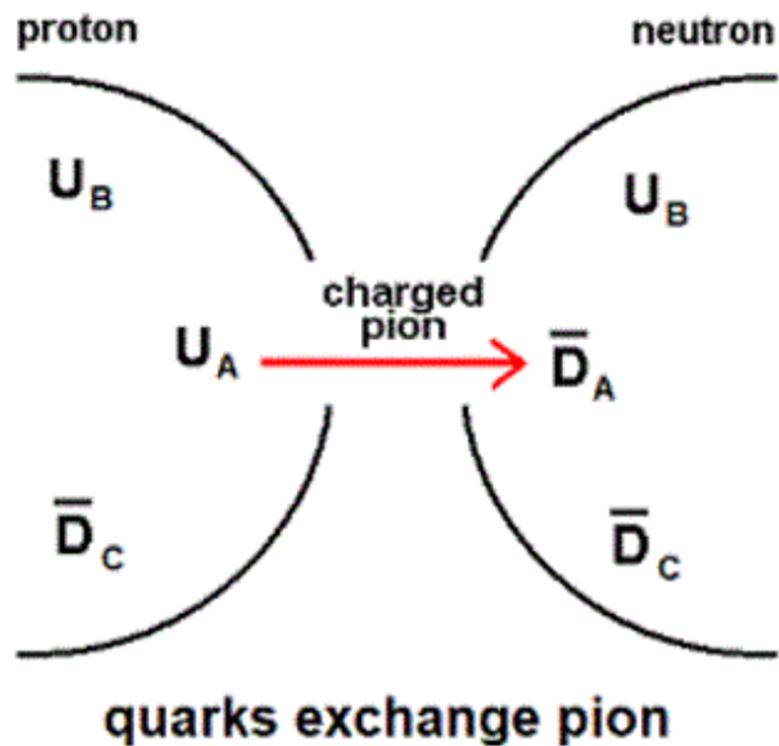
(a) Coulomb repulsion - protons repel each other through the long-range electromagnetic force, thus tending to

push nucleons further apart.

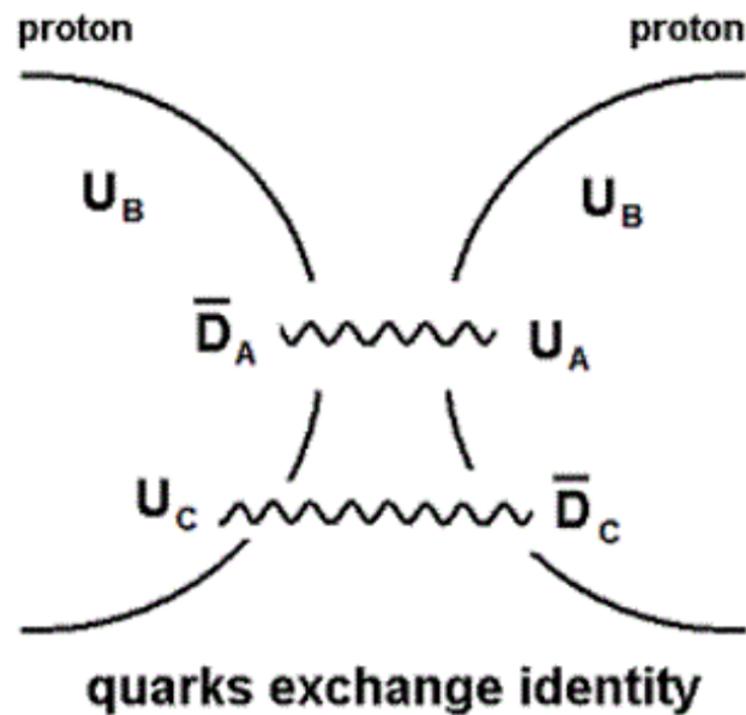
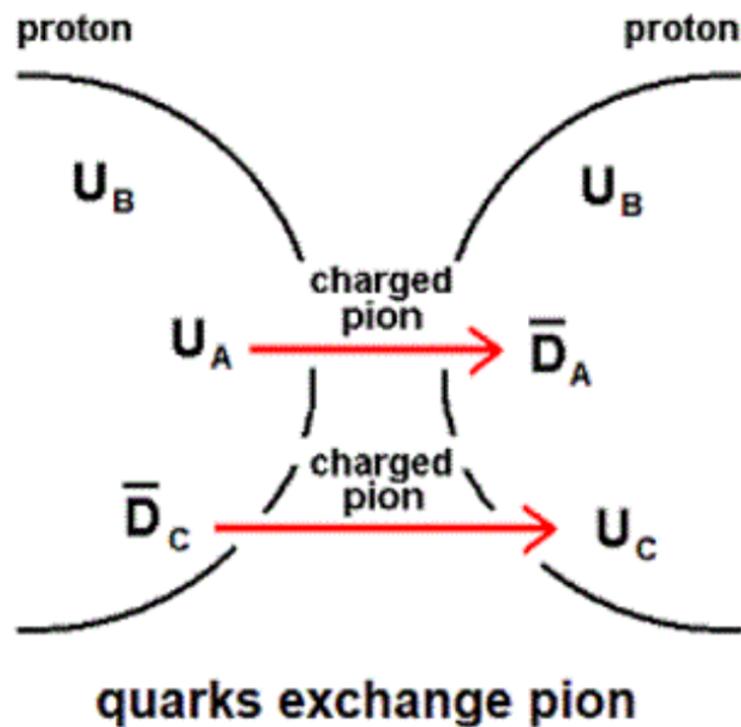
(b) Nucleon attraction - protons and neutrons attract each other through the short-range strong force, thus tending to pull the nucleons closer together.

The stability of a nuclide depends mainly on this balance of forces, and on its ratio of neutrons to protons.

**Figure 19 - Strong Interaction Between Proton And Neutron**



**Figure 20 - Strong Interaction Between Non-Identical Protons**



# Deuterium Nucleus

## 1. Introduction

The nucleus of deuterium consists of one proton and one neutron, permanently bound together. Deuterium is a stable nucleus. The deuterium nucleus can theoretically be built in two slightly different ways. This could affect the strength of the bonding between the proton and the neutron.

## 2. Differing isomeric form

Suppose we build a deuterium nucleus using a proton and a neutron of differing isomeric form. In every one of the six different such p-n pairs there is only one strong pair. So, a strong interaction can occur only between the two quarks forming the strong pair. The other two quarks are identical in both nucleons.

eg. uud and dud share a strong pair for quark(A).

eg. uud and udd share a strong pair for quark(B).

eg. duu and dud share a strong pair for quark(C).

We shall examine a specific example:

proton(C) + neutron(B)

ie. uud + dud

In this case, the strong pair is composed of the A isomer quarks. We shall keep the two nucleons fixed at their location, but close enough that they can interact. Recall that only the quarks forming the strong pair actually move in space during an interaction. The other two constituent quarks in each nucleon do not move in the interaction.

An initial strong interaction involving the A quarks causes each nucleon to change quark composition, nucleon type, and isomeric form. The proton(C) uud thus changes into a neutron(B) dud, and the neutron(B) dud changes into a proton(C) uud. The two nucleons exchange identity instantaneously, without moving physically in space. This occurs because the two quarks of strong pair A appear to have swapped location, each ending up in the other nucleon.

When a second strong interaction occurs, again involving the two quarks of isomeric form A, the two nucleons exchange identity again, reversing the effects of the first interaction. Each nucleon - at its location - has now regained its initial identity.

Figure 21 (at end of article) shows that each nucleon at its location will keep changing from a proton(C) to a neutron(B) to a proton(C) etc in an endless cycle. The initial composition of the nucleus is maintained over time, with the isomeric composition of the p-n pair remaining constant.

The above pattern applies to all deuterium nuclei made from a p-n pair of differing isomeric form. The isomeric form of the quarks that interact will differ from one p-n pair to another.

## 3. Complementary p-n pairs

A proton bound to a neutron of like isomeric form is referred to as a **complementary p-n pair**. In such a pair, all three quarks (A, B, and C) differ in the two nucleons, so there are three strong pairs. There are three different complementary p-n pairs, named A, B, and C according to the isomeric form of the nucleons that form it.

| Pair A                           | Pair B                           | Pair C                           |
|----------------------------------|----------------------------------|----------------------------------|
| <p><b>duu</b><br/><b>udd</b></p> | <p><b>udu</b><br/><b>dud</b></p> | <p><b>uud</b><br/><b>ddu</b></p> |

In general, a strong interaction can occur in any one of the three strong pairs. But note that in each specific complementary p-n pair, interaction involving one of the strong pairs is precluded because it would result in the formation of two delta baryons (delta-plus-plus and delta-minus) that are together heavier than the mass of the two interacting nucleons. The strong pair that cannot be the locus of a strong interaction is the one that corresponds to the isomeric form of the two nucleons.

Example: Complementary p-n pair C = proton(C) + neutron(C)

The quarks of strong pair C cannot interact:

$uud + ddu \Rightarrow uuu + ddd$  (not possible)

Strong pairs A and B can interact

When the two nucleons of a complementary p-n pair interact at one of the two allowed strong pair loci, both nucleons change to a different (but same for both) isomeric form. So, a strong interaction converts a complementary p-n pair into a different complementary p-n pair.

Example: Complementary p-n pair C = proton(C) + neutron(C)

$uud + ddu \Rightarrow$  A quarks interact  $\Rightarrow dud + udu$  (complementary p-n pair B)

$uud + ddu \Rightarrow$  B quarks interact  $\Rightarrow udd + duu$  (complementary p-n pair A)

#### 4. Same isomeric form

We now build a deuterium nucleus using a proton and a neutron of same isomeric form, ie. using one of the three complementary p-n pairs. Again, we shall hold the two nucleons fixed in space.

Example: proton(C) + neutron(C)

ie.  $uud + ddu$

When a strong interaction occurs, the proton and the neutron do not exchange identity. The proton and the neutron do change into each other, but they both change to a different isomeric form (same for both).

Figure 22 shows how successive strong interactions cause one complementary p-n pair to change into another.

The initial complementary p-n pair (type C) [at upper left in diagram] can change into a B complementary p-n pair if a strong interaction occurs at the A quark locus.

$uud + ddu \Rightarrow dud + udu$

ie. proton(C) + neutron(C)  $\Rightarrow$  neutron(B) + proton(B)

This change can be reversed with a second interaction involving the same strong pair at the A quark locus. But if instead the second interaction occurs at the C quark locus, the two nucleons will change to an A type complementary p-n pair.

$dud + udu \Rightarrow duu + udd$

ie. neutron(B) + proton(B)  $\Rightarrow$  proton(A) + neutron(A)

We can see that each nucleon cycles from being a proton to being a neutron to being a proton etc, while also cycling through the three different isomeric forms. The overall effect is that there is mixing of the three different complementary p-n pairs (Figure 23).

So, a deuterium nucleus built initially from two nucleons that form a complementary p-n pair can be considered to be a superposition of all the three different complementary p-n pairs.

## 5. Conclusion

Deuterium is stable because the frequent strong interactions do not allow time for the neutron to decay (through the weak charged force). Theoretically, a deuterium nucleus formed from a complementary p-n pair is better bound than one formed from two nucleons of unlike isomeric form. In my opinion, only the complementary form of deuterium exists in nature.

As the proton and the neutron change into each other, the two nucleons attract each other and move to a limited extent in space about each other. Strong interactions occur very frequently, so the two nucleons are perpetually changing into each other, also moving about each other, while remaining bound together. It is thus not possible to keep tabs on a particular single nucleon.

## 6. Binding considerations

Deuterium data:

Stable = yes.

Binding energy per nucleon = 1.1 MeV (lowest of all nuclei).

Average distance between nucleons = 2.2-3.2 fermi.

Binding = loose.

As the deuterium nucleus contains only one proton, there is no Coulomb repulsion. The strong force acting between the two nucleons is thus unopposed. Therefore, we would expect the deuterium nucleus to be very well bound, with a large binding energy. In fact, it is not so. The binding energy per nucleon (1.1 MeV) is the lowest of all nuclei, and the nucleus is described as being loosely bound. In addition, the proton and the neutron appear to be further apart than one would expect, the average distance between them being about 2 fermi. In large nuclei, nucleons are about 1.7 fermi apart. We deduce that the frequency of strong interactions in the p-n pair is not very high. It is high enough to ensure a stable nucleus, but it does not result in very good binding. The reason could be that the proton has only one possible partner for a strong interaction. Maybe, if there were two neutrons instead of one in the immediate vicinity, strong interactions would occur at a higher rate, and binding between the three nucleons would be better.

Figure 21 - Deuterium Nucleons Exchange Identity

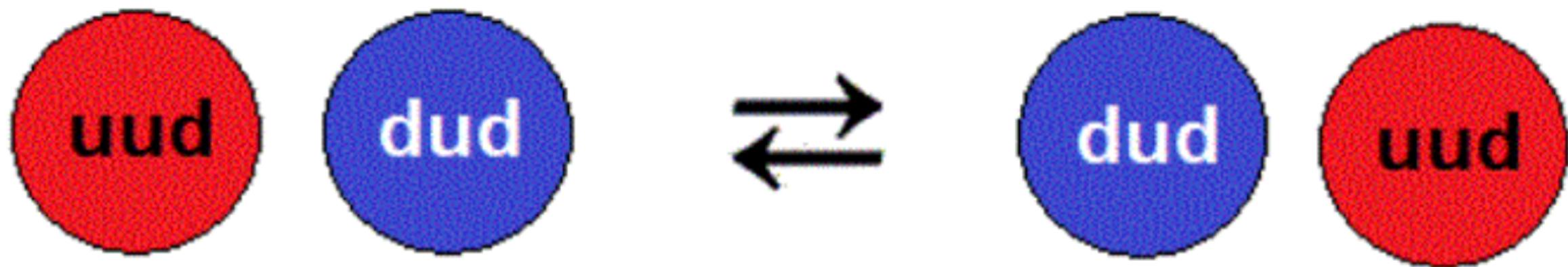


Figure 22 - Mixing Of Deuterium Complementary P-N Pairs (Fixed Nucleons)

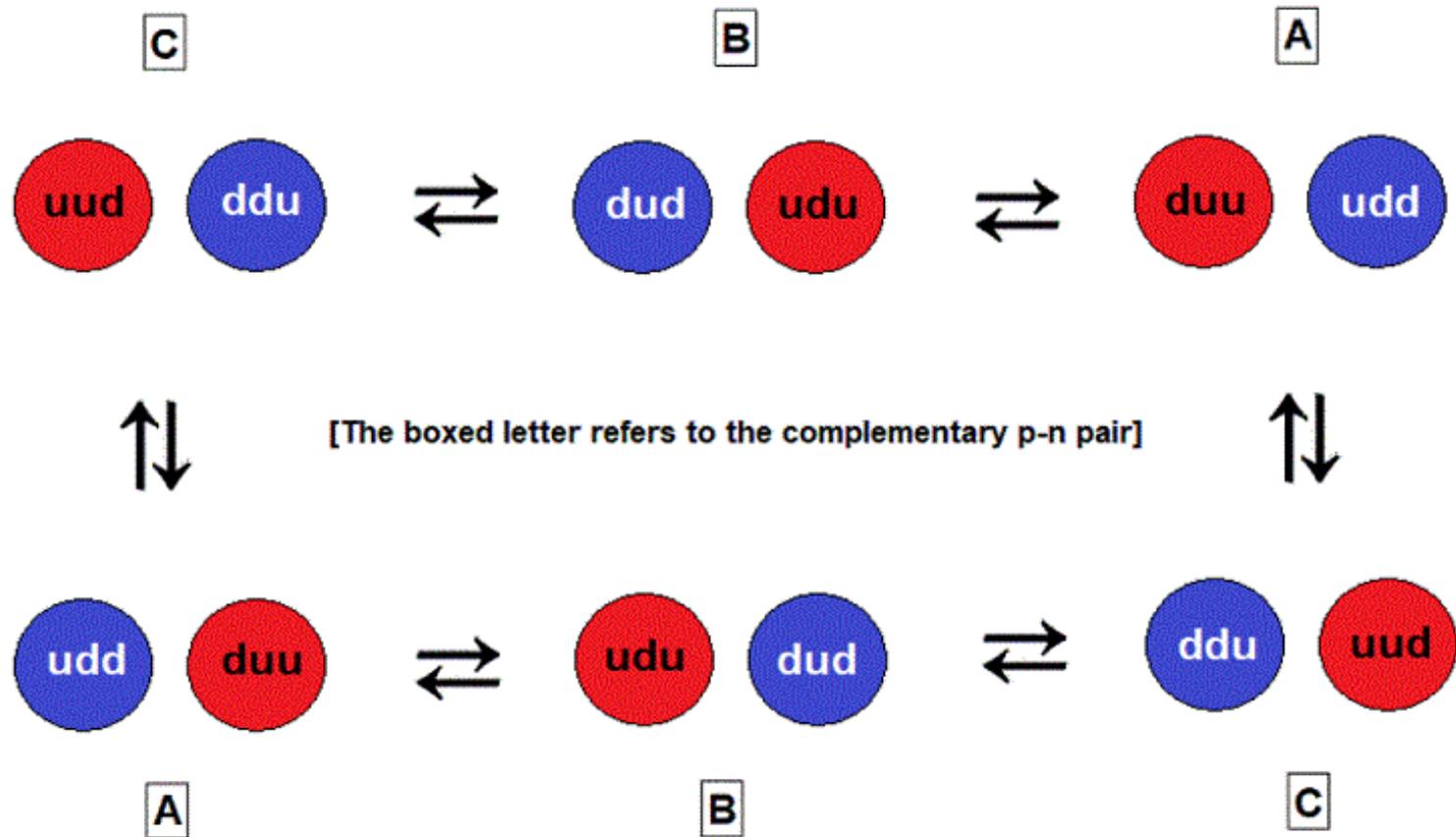
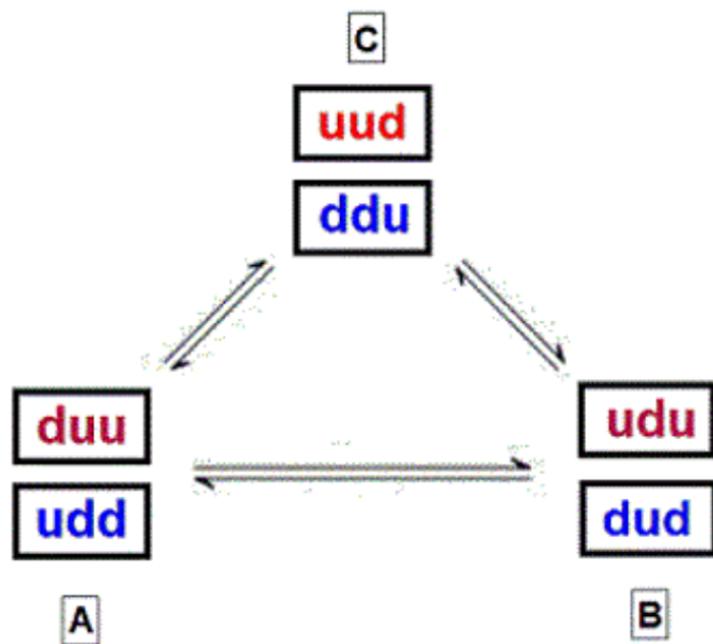


Figure 23 - Net Mixing Of Deuterium Complementary P-N Pairs



[The proton is shown arbitrarily above the neutron]

# Nuclei

## 1. Nuclei with three nucleons

There are only two nuclei that are composed of three nucleons. These are tritium ( $1p+2n$ ) and helium-3 ( $2p+1n$ ). Tritium is unstable, having a half-life of 12 years. He-3 is stable. In these nuclei, bonding between nucleons is more diverse than in deuterium. The single proton in tritium, and the single neutron in He-3, has two potential partners (of different nucleon type) with which to form a bond. This affects the stability of the nucleus. In He-3, the two protons repel each other electromagnetically, but this feature is missing in tritium (one proton only).

## 2. Building a tritium nucleus

A tritium nucleus can theoretically be built from three initial nucleons in two different ways, with or without an initial complementary p-n pair.

(1) Three nucleons of mutually different isomeric form.

Eg: proton(A) + neutron(B) + neutron (C).

Such a nucleus will maintain its overall isomeric composition over time. A complementary p-n pair cannot ever form.

(2) A complementary p-n pair plus another neutron of different isomeric form.

Eg: proton(A) + neutron(A) + neutron (C).

If proton(A) interacts with neutron(A), both nucleons shift to either the (B) or the (C) isomeric form. If instead proton(A) interacts with neutron(C), the two nucleons change into each other. So, all three nucleons interact with each other. After many strong interactions, the nucleus becomes a superposition of all three isomeric forms of both the proton and the neutron. An instantaneous snapshot of the nucleus would reveal one of three possible compositions:

proton(A) + neutron(A) + neutron (C)

proton(B) + neutron(B) + neutron (C)

proton(C) + neutron(C) + neutron (C).

In my opinion, only the complementary form of tritium exists in nature, as it is better bound.

## 3. Building a He-3 nucleus

A He-3 nucleus - like tritium - can theoretically be built from three initial nucleons with or without an initial complementary p-n pair.

(1) Three nucleons of mutually different isomeric form.

Eg: proton(A) + proton(B) + neutron (C).

Such a nucleus will maintain its overall isomeric composition over time. A complementary p-n pair cannot ever form.

(2) A complementary p-n pair plus another proton of different isomeric form.

Eg: proton(A) + neutron(A) + proton (C).

If neutron(A) interacts with proton(A), both nucleons shift to either the (B) or the (C) isomeric form. If instead neutron(A) interacts with proton(C), the two nucleons change into each other. So, all three nucleons interact with each other. After many strong interactions, the nucleus becomes a superposition of all three isomeric forms of both the proton and the neutron. An instantaneous snapshot of the nucleus would reveal one of three possible compositions:

proton(A) + neutron(A) + proton (C)

proton(B) + neutron(B) + proton (C)  
proton(C) + neutron(C) + proton (C).

In my opinion, only the complementary form of helium-3 exists in nature, as it is better bound.

#### 4. Varied bonding

In tritium (1p+2n) bonding between nucleons is more varied than in deuterium (1p+1n). The single proton has two potential neutron partners for each strong interaction. So in a strong interaction it will bond with one neutron, but in the next strong interaction it will bond with the other neutron. Interactions thus occur more frequently than they do in deuterium.

He-3 (2p+1n) has the same bonding patterns as tritium. The single neutron can bond with either one or the other of the two protons at each strong interaction. Interactions are thus more frequent than in deuterium.

#### 5. Binding considerations

Tritium:

Stable = no (beta decay; half-life of 12 years).

Binding energy per nucleon = 2.83 MeV.

Average distance between nucleons = 1.8 fermi.

Binding = good.

Helium-3:

Stable = yes.

Binding energy per nucleon = 2.6 MeV

Average distance between nucleons = 1.7 fermi.

Binding = good.

Theoretically we would expect that adding a neutron to deuterium would increase the frequency of strong interactions, yielding a better bound nucleus. Instead, adding a neutron results in an unstable nucleus. But note that tritium has a half-life of 12 years, ie. it is almost stable. And the binding energy per nucleon is higher (2.83 MeV) than that of deuterium (1.1 MeV). So, probably, nuclear bonding actually does improve by adding a neutron to deuterium.

But adding a neutron, creates a new problem. The neutron is inherently an unstable particle, and in isolation decays through the weak charged force into a proton with a half-life of about 10 minutes. Inside stable nuclei, though, neutrons appear to be stable. In fact, they do not decay because of frequent strong interactions with protons. So, it seems that in tritium a single proton cannot bind often enough with two neutrons, to keep both neutrons from decaying. Eventually one of them undergoes beta decay and turns into a proton, resulting in the formation of a stable He-3 nucleus.

In helium-3, there are two protons that can interact with a single neutron. The increased rate of strong interactions now prevents the neutron from decaying. So He-3 is stable. The binding energy per nucleon and the average distance between nucleons are similar to that of tritium, confirming that three nucleons are better bound than two. In this nucleus Coulomb repulsion between the two protons is relatively weak, because this force increases in proportion to the number of protons in the nucleus. So, this does not reduce binding by an appreciable amount. The effect of more frequent strong interactions wins easily.

#### 6. Other helium nuclides

Since He-4 is composed of four nucleons, it follows that it cannot be constructed from initial nucleons with mutually different isomeric forms. At least one complementary p-n pair must be present from the start. Thus only the complementary form of He-4 exists. [This reasoning applies for all nuclei with more than three nucleons].

Each nucleon has two bonding partners of the other type within easy reach. Strong interactions are thus very frequent.

Helium-4:

Stable = yes.

Binding energy per nucleon = 7.0 MeV (high)

Average distance between nucleons = 1.3 fermi (low).

Binding = extremely good.

He-4 is the best bound among hydrogen and helium isotopes. Its binding energy per nucleon is high (7.0 MeV), not far from the peak value for all nuclides (8.79 MeV in iron-56). Consequently, the nucleus is also more compact, with the average distance between nucleons being only 1.3 fermi.

Up to six additional neutrons can be bound temporarily to form unstable isotopes. These nuclides have negligible half-lives (less than a second). They are thus practically not bound, existing fleetingly before undergoing beta-decay or neutron ejection.

## 7. Notes on nuclei

Nucleus - A large nucleus is an agglomeration of nucleons of all the six different types - proton(A), proton(B), proton(C), neutron(A), neutron(B), and neutron(C). The basic bond that holds the nucleus together is the proton-neutron bond. A nucleon can interact with a nucleon of different type in its immediate neighbourhood. Two interacting nucleons can be of unlike isomeric form (in which case they exchange identity), or they can be of same isomeric form (in which case they exchange nucleon type, but they both change to a different shared isomeric form, eg. from both being of isomeric form A to both being of isomeric form B).

Deuterium - The six different nucleons are also present in the deuterium nucleus, but not at the same instant. The single complementary p-n pair of which deuterium is composed, with successive strong interactions, iterates through the three different complementary pairs (ie. through all six different nucleons). All nuclei contain at least one p-n complementary pair.

Hybrid nucleon - A nucleon inside a nucleus should be considered to be a hybrid nucleon. It keeps changing back and forth from being a proton to being a neutron back to being a proton etc. Even the isomeric form changes all the time, cycling irregularly through all three forms, as a result of successive strong interactions. A nucleon can thus be considered to be a superposition of the six different nucleons.

Forces in nucleus - In all nuclei with  $Z > 1$ , there is a balance between two opposing forces:

(a) Coulomb repulsion - protons repel each other through the long-range electromagnetic force.

(b) Nucleon attraction - protons and neutrons attract each other through the short-range strong force.

Coulomb repulsion increases in proportion to the number of protons. As the electromagnetic force is of long-range, a given proton will be repelled by the cumulative effect of all the other protons within the nucleus. This is why as the number of protons increases, the number of neutrons to achieve stability tends to increase at a higher pace. The strong force is of short range. So, a given nucleon in a large nucleus can only interact with its immediate neighbours, and is not affected by nucleons further away.

Transient pairing - In deuterium, the proton and the neutron necessarily form a permanently-bound pair (while changing into each other). This is an exceptional situation. In all other nuclei, a particular proton bound permanently to an adjacent particular neutron (with exchange of identity) is not encountered. Such a 'for-ever' stable dinucleon would not interact with other adjacent nucleons. A nucleon interacts with one near neighbour and then with a different near neighbour, changing partners all the time.

Nuclear model - Nuclei - except possibly those with very few nucleons - can be modelled as a collection of spheres (nucleons) packed closely together. Because the strong force has a short range, any nucleon interacts only with a nucleon of different type located in its immediate vicinity. Immediate neighbour nucleons can vary in type (proton or neutron) or in isomeric form (A, B, or C). In a nucleus there is a complex web of strong

interactions. An imaginary instantaneous 'distribution map' showing which nucleon is a proton and which is a neutron will keep changing from one instant to the other. Even the isomeric form of each nucleon keeps changing from one interaction to another.

# Observable Mesons

## 1. Introduction

The virtual mesons that bind together constituent quarks inside baryons are not in the singlet state; these mesons are unobservable.

All observable mesons are in the singlet state.

An observable (real) meson is composed of two quarks of same isomeric form. These are bound together by the quark-binding force; the electromagnetic force between them is either attractive or repulsive.

Recall that higher-generation quarks are merely internal excited states of the quarks of the first generation. An S+ quark is just a D+ quark in which the three constituent preons orbit around each other with more energy.

Using only the first-generation quarks, a basic set of four mesons (in the ground state) can be built. These are Pi-plus, Pi-minus, Pi-zero, and Eta-zero. All other mesons can be derived theoretically from this basic set by (a) internal excitation, meaning that one or both quarks forming a meson is of higher generation; or (b) orbital excitation, meaning that the two quarks orbit around each other with increased momentum; or (c) both these factors.

Each and every meson comes in three different isomeric forms; but these always mix together.

We now examine the nine pseudoscalar mesons (angular momentum  $J = 0$ , quarks with anti-parallel spins) built from U, D, and S quarks.

Mass of quarks is  $S > U > D$ .

### 1. Charged pion (140 MeV)

Pi-plus = Pos U-quark + Pos D-quark; Pi-minus = Neg U-quark + Neg D-quark

The pi-plus has three isomeric forms:

PosU(A) + PosD(A)

PosU(B) + PosD(B)

PosU(C) + PosD(C)

The two quarks that make up a real charged pion are bound together by the quark-binding force; they exchange a virtual meson between themselves; the two quarks exchange identity, and are bound together; in this process there is no change in their isomeric form. The exchanged virtual meson is not in the singlet state; it has a net electric charge of  $1/3e$ ; it is composed of the two members of a strong pair. Note that all four quarks involved (two constituent quarks in real charged pion, and two quarks in virtual binding meson) have the same isomeric form.

PosU(A) at X + borrow[PosD(A)][NegD(A)] => PosD(A) + meson[PosU(A)][NegD(A)]

PosD(A) at Y + meson[PosU(A)][NegD(A)] => PosU(A) + return[PosD(A)][NegD(A)]

The three isomeric forms of the charged pion can change into each other through the weak charged force, via an intermediate virtual W-boson stage. A pi-plus is thus a superposition of the three different forms.

eg. PosU(A) + PosD(A) => W-plus

then W-plus => PosU(B) + PosD(B) => pi-plus

Decay is through the weak charged force. The two quarks first reconstitute a W-plus boson, which then decays. Recall that in this process a quark-antiquark pair enters the vacuum, but sometimes it can instead appear as a real meson in the decay products.

Lifetime =  $10^{-8}$  s.

Decay1 (99.9%)

[Pi-plus => Pos Muon + Muon neutrino]

Pi-plus => W-plus (reconstitution)

then W-plus => Pos Muon + Muon neutrino

Decay2 (very rare)

[Pi-plus => Positron + Electron neutrino]

Pi-plus => W-plus

then W-plus => Positron + Electron neutrino

Decay3 (very rare)

[Pi-plus => Pi-zero + Positron + Electron neutrino]

Pi-plus => W-plus + real Pi-zero

then W-plus => Positron + Electron neutrino

## 2. Pi-zero (135 MeV)

Pi-zero = Pos D-quark + Neg D-quark

Three isomeric forms (each is a quark-antiquark pair):

PosD(A) + NegD(A)

PosD(B) + NegD(B)

PosD(C) + NegD(C)

These forms cannot change into each other through the weak charged force, but they can do so through the quark-binding force. A pi-zero is thus a superposition of the three different forms. There is no antiparticle.

The two quarks that compose a pi-zero are bound together by the quark-binding force; they exchange a virtual meson between themselves; they exchange identity, with the proviso that both quarks change to a different isomeric form (same for both quarks); they are thus bound together. The exchanged virtual meson is not in the singlet state; it has a net electric charge of  $2/3e$ ; it is composed of two quarks of same sign but of different isomeric form.

Example: PosD(A) + NegD(A) => PosD(B) + NegD(B)

PosD(A) at X + borrow[PosD(B)][NegD(B)] => NegD(B) + meson[PosD(A)][PosD(B)]

then NegD(A) at Y + meson[PosD(A)][PosD(B)] => PosD(B) + return[PosD(A)][NegD(A)]

The two quarks making up the pi-zero are also bound together by an attractive electromagnetic force.

Decay is by annihilation (electromagnetic force); the energy released can create photons and/or positron-electron pairs.

Lifetime =  $10^{-17}$  s.

Decay1 (99%)

Pi-zero => two photons

Decay2 (1%)

Pi-zero => photon + positron-electron pair

Pi-zero => two positron-electron pairs

### 3. Eta-zero (548 MeV)

Eta zero = Pos U-quark + Neg U-quark

Three isomeric forms; each is a quark-antiquark pair; forms can change into each other through quark-binding force; superposition of forms; no antiparticle.

Decay is by annihilation (electromagnetic force); the energy released can create photons and/or pions.

Lifetime =  $10^{-19}$  s.

Decay1 (40%)

Eta-zero => two photons

Decay2 (33%)

Eta-zero => Pi-zero + Pi-zero + Pi-zero

Decay3 (23%)

Eta-zero => Pi-zero + Pi-plus + Pi-minus

Decay4 (4%)

Eta-zero => Pi-plus + Pi-minus + photon

### 4. Charged kaon (493 MeV)

K-plus = Pos U-quark + Pos S-quark

K-minus = Neg U-quark + Neg S-quark

The K-plus has three isomeric forms; quarks of different generation are bound together by quark-binding force; isomeric forms can change into each other through weak charged force; superposition of forms.

Decay is through the weak charged force.

Lifetime =  $10^{-8}$  s.

Decay1 (63%)

[K-plus => Pos Muon + Muon neutrino]

K-plus => W-plus (reconstitution)

then W-plus => Pos Muon + Muon neutrino (leptonic decay)

Decay2 (21%)

[K-plus => Pi-zero + Pi-plus]

K-plus => W-plus + real Pi-zero

then W-plus => Pi-plus (hadronic decay)

Decay3 (3%)

[K-plus => Pi-zero + Pos Muon + Muon neutrino]

K-plus => W-plus + real Pi-zero

then W-plus => Pos muon + Muon neutrino (leptonic decay)

Decay4 (5%)

[K-plus => Pi-zero + Positron + Electron neutrino]

K-plus => W-plus + real Pi-zero

then W-plus => Positron + Electron neutrino (leptonic decay)

Decay5 (5%)

[K-plus => Pi-plus + Pi-plus + Pi-minus]

PosS => NegU + W-plus  
PosU => NegD + W-plus  
two quarks combine to form Pi-minus  
then 2 W-plus => 2 Pi-plus (hadronic decay)

## 5. K-zero (497 MeV)

Theoretically, there are two different K-zeros.  
K-zero-1 = Pos D-quark + Neg S-quark  
K-zero-2 = Pos S-quark + Neg D-quark  
Each K-zero comes in three isomeric forms.

The two K-zeros can change into each other (mixed strangeness) through the combined action of the weak charged force and the quark-binding force. At the same time, the isomeric form (preon composition) is changed. So, the K-zero is actually a superposition of the two particles (K-zero-1 and K-zero-2) and of the three different isomeric forms.

Example: starting from K-zero-1(A)  
One quark emits W-plus  
PosD(A) at X => NegU(A) + W-plus  
other quark absorbs it  
NegS(A) at Y + W-plus => PosU(A)  
now we have a quark-antiquark pair  
PosU(A) + NegU(A)  
quark-binding force can change their isomeric form  
(mechanism discussed above)  
=> PosU(B) + NegU(B)  
now a W-plus exchange between the two quarks can  
(a) restore the original K-zero-1 meson, but in different isomeric form  
=> PosD(B) + NegS(B) or  
(b) generate a K-zero-2 (of different isomeric form from the initial K-zero-1)  
=> PosS(B) + NegD(B)

The two quarks composing a K-zero, being of different generation, cannot annihilate each other. Decay is through the weak charged force; some rare decays occur through the weak neutral force.

Lifetime (K-short) =  $10^{-11}$  s.

Lifetime (K-long) =  $10^{-8}$  s.

see further below for why two lifetimes are given.

Decays are shown for K-zero-1 (K-zero-2 decays to the exact same products).

Decay1 (two charged pions)  
[K-zero-1 => Pi-plus + Pi-minus]  
NegS => PosU + W-minus  
PosD + PosU => Pi-plus  
then W-minus => Pi-minus (hadronic decay)

Decay2 (two neutral pions)  
[K-zero-1 => Pi-zero + Pi-zero]  
NegS => PosU + W-minus  
PosD + W-minus => NegU  
PosU + Neg U-quark annihilate  
two Pi-zero created from vacuum

Decay3 (three mixed pions) negS + posD  
 [K-zero-1 => Pi-plus + Pi-minus + Pi-zero]  
 NegS => PosU + W-minus  
 PosD => NegU + W-plus  
 PosU + NegU => annihilate  
 one Pi-zero created from vacuum  
 then W-minus => Pi-minus (hadronic decay)  
 then W-plus => Pi-plus (hadronic decay)

Decay4 (three neutral pions)  
 [K-zero-1 => Pi-zero + Pi-zero + Pi-zero]  
 PosD => NegU + W-plus  
 NegS + W-plus => PosU  
 PosU + NegU annihilate  
 three Pi-zeros created from vacuum

Note: In some decays, the Neg S-quark can turn into a Neg D-quark by emitting a virtual Z-boson; the Z-boson decays to a fermion-antifermion pair; the two D-quarks then produce a pi-zero, or else annihilate to produce two pi-zeros from the released energy. A Neg S-quark can also emit and reabsorb a virtual W-boson, so turning into a Neg D-quark; the two D-quarks can now produce a pi-zero directly, or annihilate and produce two pions or other products.

A beam of neutral kaons contains both K-zero-1 and K-zero-2 (which change into each other). Close to the beam origin, decay is almost exclusively (99.9%) to two pions; semi-leptonic decay to pion plus leptons is very rare (0.1%). This branching ratio is attributed to a particle called K-zero-short. At a greater distance from the beam origin, semi-leptonic decay to pion plus leptons is common (68%); decays to three pions accounts for 32% of decays. This branching ratio is attributed to a particle called K-zero-long. But, in fact, decays that occur quickly are observed close to the beam origin, while decays that take longer are observed at a greater distance from the beam origin. K-zero-short and K-zero-long particles do not exist.

## 6. Eta-prime-zero (958 MeV)

Eta-prime-zero = Pos S-quark + Neg S-quark

Three isomeric forms; each is a quark-antiquark pair; forms can change into each other through quark-binding force; superposition of forms; no antiparticle.

Decay is by annihilation (electromagnetic force); the energy released can create mesons.

Lifetime =  $10^{-21}$  s.

Decay1 (43%)  
 Eta-prime-zero => Pi-plus + Pi-minus + Eta-zero

Decay2 (29%)  
 Eta-prime-zero => Rho-zero + photon

Decay3 (23%)  
 Eta-prime-zero => Pi-zero + Pi-zero + Eta-zero

Decay4 (2%)  
 Eta-prime-zero => two photons

# Gauge Theory Of Secondary Forces

## 1. Introduction

As we saw, all secondary forces arise through the vacuum shuttle mechanism. The basic process is that a preon-antipreon pair arises from the vacuum, and collides with a constituent preon inside an elementary fermion. The constituent preon is replaced with a preon coming from the vacuum.

The preon-binding force (a preonic force) binds together three preons of same sign to form a particle in the integer state. A stable particle is the result. Replacing a preon in an elementary fermion with a different preon is only possible if the new particle that results is also in the integer state. The integer state must be preserved.

A gauge theory can model a physical 'preon replacement' using a mathematical 'preon transformation'. Such a theory must therefore be applied to preons. It must be based on the internal symmetry of **preon isospin**. The associated conserved quantity is **species charge**. When a preon is transformed into a different preon, at least one electric species suffers a change in value. Recall that conservation of charge must be respected separately for each one of the three electric species.

The gauge group is composed of the twelve different preons. Theoretically, any preon can be transformed into any one of the twelve different preons.

## 2. Weak preon force

The specific transformation that explains the weak preon force is:

Transformation to compatible preon.

Recall that two preons are compatible with each other if they are of same sign and belong to different preon groups.

When a constituent preon is transformed into a compatible preon, a local violation of conservation of charge occurs. This must be compensated with a second preon transformation that is the inverse of the first one. This must be effected within the same elementary fermion. In practice, two compatible preons within the same elementary fermion exchange a gluon between themselves. They thus exchange identity, and the weak preon force acts between them to help bind them together.

## 3. Superweak force

The specific transformation that explains the superweak force is:

Transformation to incompatible preon pair partner.

When a preon is transformed into its incompatible preon pair partner, a local violation of conservation of charge occurs. This cannot be corrected by any transformation occurring within the same fermion. But it can be corrected if a transformation occurs in an adjacent fermion. This can occur in two ways:

- (1) eg. If, in fermion A,  $PE1 \Rightarrow PD1$ , then, in fermion B,  $PD1 \Rightarrow PE1$ .
- (2) eg. If, in fermion A,  $PE1 \Rightarrow PD1$ , then, in fermion B,  $NE1 \Rightarrow ND1$ .

In practice, two preons located in different fermions exchange an X-boson between themselves. The interacting preons can be either the two members of an incompatible preon pair, or a preon and its antipreon.

#### 4. Weak charged force

The specific transformation that explains the weak charged force is:

Transformation to preon of different sign and type (same preon group).

For this force, all three constituent preons must undergo the same transformation at the same time. Three Y-bosons are generated, which combine to form a W-boson. The W-boson leaves the emitting fermion and is absorbed by another fermion.

The overall violation of conservation of charge in the emitting fermion is compensated by the inverse overall violation in the absorbing fermion.

#### 5. Weak neutral force

The specific transformation that explains the weak neutral force is the same as for the weak preon force:

Transformation to compatible preon.

All three constituent preons must undergo the above transformation at the same time, such that they change into each other. The overall preon composition of the fermion does not change.

eg. In an electron:

At X, NE1 => NE2

At Y, NE2 => NE3

At Z, NE3 => NE1

Note that each of the three preon transformations causes a change in species charge at its location, but taken together there is no overall violation of charge conservation within the fermion. Therefore no compensating violations need occur in another fermion.

Each preon emits a gluon, and the three gluons combine to form a Z-boson. The Z-boson leaves the emitting fermion and is absorbed by another fermion.

When the Z-boson is absorbed, momentum is transferred to the three constituent preons. The preon-antipreon pairs contained within the Z-boson return to the vacuum. No preon replacements in the absorbing fermion need occur.

#### 6. Forces at quark level

The vacuum shuttle mechanism also operates at the quark level. The basic process is that a quark-antiquark pair arises from the vacuum, and collides with a constituent quark in a baryon. The constituent quark is replaced with a quark coming from the vacuum.

All quarks are in the integer state. We saw that quarks bind together spontaneously in groups of three to form baryons. These particles are more stable as they are in the singlet state. So, any change in the quark composition of a baryon must preserve the singlet state.

A gauge theory of the quark-based forces must be based on **quark isospin**.

The gauge group is composed of the twelve different quarks. Theoretically, any quark can be transformed into any one of the twelve different quarks. Mesons must couple to quarks, and be of short range.

Note that a quark is just a packet of three preons that is moved by the vacuum shuttle mechanism as a unit. When a quark is transformed into a different quark, the preon composition of the quark changes. It follows that the ultimate internal symmetry is preon isospin (of more than one preon). The associated conserved quantity is therefore again species charge. When a quark is transformed into a different quark, at least two electric species suffer a change in value.

## 7. Quark-binding force

The specific transformation that explains the quark-binding force is:

Transformation to compatible quark.

When a quark is transformed into a compatible quark, a local violation of conservation of charge occurs. This must be compensated with a second quark transformation within the same baryon that is the inverse of the initial one. In practice, two compatible quarks within the same baryon exchange a meson between themselves. They thus exchange identity, and the quark-binding force acts between them to bind them together.

## 8. Strong force

The specific transformation that explains the strong force is:

Transformation to strong pair partner.

The two members of a strong pair, located in different baryons (in practice nucleons), exchange identity by exchanging a charged pion (singlet) between themselves. As a result, the two interacting nucleons change into each other and attract each other.

# Electromagnetic Force

## 1. Introduction

This long-range force originates from electric preons, in particular from the two elementary charges each one carries. This force is thus a preonic force. Dipolar preons do not take part in electromagnetic interactions. In summary, all electric preons belonging to the same preon group, located in separate elementary fermions, interact with each other by exchange of a massless virtual boson. Electric preons of different preon groups do not interact with each other. In an electromagnetic interaction, electric preons of same sign repel each other, and electric preons of unlike sign attract each other.

## 2. Origin

An electric preon can emit the two charges it carries together with their anticharges. It does this by borrowing the appropriate charge-anticharge pairs from the vacuum. The emitting electric preon will be left unchanged, carrying its original charges. The two emitted charge-anticharge pairs together constitute a virtual boson that transmits the electromagnetic force. This boson is called the **ep-boson** (ep stands for electric preon), and it has no net electric charge. It is not composed of preons, and is thus massless. In consequence, it can be emitted away from the elementary fermion in which the emitting electric preon is located.

Example: NE1 preon => ep-boson[E1-1/2][E2-1/2][E1+1/2][E2+1/2].

Boson notation: The elementary charges identical to those of the emitting preon are written first. These are called *leading charges*, and they are the charges that interact with the charges on the electric preon that will absorb the boson.

The ep-boson is preon-group specific. So, there are obviously three different ep-bosons, one per preon group. In the example above, the ep-boson emitted by an NE1 preon can be absorbed only by another NE1 preon (resulting in repulsion) or by a PE1 preon (resulting in attraction). In either case, the absorbing preon is located in an elementary fermion separate from the one in which the emitting preon is located.

In the example above, suppose the ep-boson emitted by an NE1 preon is absorbed by a PE1 preon. The leading charges of the ep-boson are of negative sign. So, when the boson collides with the absorbing PE1 preon, the boson's charges will interact with the preon's positive charges, resulting in attraction.

The ep-boson is always a virtual boson, and cannot be observed as a real particle.

## 3. Electromagnetic interaction

Any two electric preons belonging to the same preon group, located in separate elementary fermions, can interact together by exchanging an ep-boson. The boson will transmit the electromagnetic force. An electromagnetic interaction causes the two interacting electric preons to either attract or repel each other, depending on their signs. The interaction does not alter preon charges. Note that there are three different streams of interactions between electric preons, one for each preon group.

Two constituent electric preons inside a charged elementary fermion (electron or U-quark) do not repel each other. This is because an ep-boson cannot be exchanged between electric preons belonging to two different preon groups.

Inside a proton, there are three electric preons belonging to the same preon group. Two are of positive sign, and are found one in each of the two U-quarks. These two preons repel each other, so the two U-quarks inside a proton repel each other. The remaining electric preon is of negative sign, and is found in the single D-quark. This

negative preon will be attracted by the positive electric preons in both U-quarks. So, the two U-quarks will attract the D-quark.

#### 4. Atom

In a hydrogen atom, the electron is held bound to the proton by three separate streams of virtual ep-bosons that are constantly being exchanged between the four positive electric preons in the two U-quarks and the three negative electric preons in the electron. There is also a single negative electric preon in the D-quark in the proton, which repels the negative electric preon of the same preon group inside the electron. What we measure is the net force of attraction.

In the ground state, the electron in a hydrogen atom is kept bound to the proton. No expenditure of energy is required. If this electron is given an input of energy, it will jump to a higher orbital. Eventually, it will return to the ground state, and will emit a real photon.

#### 5. Photon

The **photon** is not the transmitter of the electromagnetic force between two electric preons. A photon is always a real particle/wave, and its job is to transfer energy and angular momentum between fermions. Virtual photons do not exist.

A photon is emitted when an electrically-charged particle in the singlet state is accelerated. Individual quarks therefore do not emit photons, while electrons and protons do.

An electron emits a photon when each one of its three constituent electric preons emits its appropriate ep-boson at the same time. The three different ep-bosons then aggregate together to form a real photon.

How does a proton emit a photon? What happens is that each of the three different electric preons of same sign (contained within the two U-quarks) emits an ep-boson according to its preon group. The three different ep-bosons then aggregate together to form a photon.

When a photon is absorbed by a charged particle in the singlet state, each ep-boson is absorbed by the appropriate electric preon according to its preon group. Emission/absorption of a photon causes changes in the angular momentum and energy of an electrically-charged particle. But there is no change in the preon composition of the particle.

A photon - being real - can be observed.

#### 6. General

In QED, the Lagrangian is invariant if the phase of the electron's wavefunction is changed by different amounts at different space locations. QED then requires the existence of the photon to maintain symmetry.

The above gauge requirement is needed because the electromagnetic properties of an electron, measured at a distance from the particle, must not depend on the relative positions of the three electric preons within the electron's volume, which varies from an instant to another as the three preons are orbiting around each other. For example, the difference in phase of the three ep-bosons that combine to form a photon must not affect the properties of the photon. The phase of the ep-boson depends on the location in space of the electric preon that emits it.

When an electron and a positron annihilate each other, their respective constituent preons pair up to form three preon-antipreon pairs. These pairs then enter the vacuum and disappear. The mass-energy of the two particles is converted into two photons.

# Gravitational Force

## 1. Introduction

This long-range force originates from dipolar preons, in particular from the two elementary charges each one carries. This force is thus a preonic force. Electric preons do not take part in gravitational interactions. In summary, all dipolar preons belonging to the same preon group, even though located in separate elementary fermions, interact with each other by exchange of a massless virtual boson. Dipolar preons of different preon groups do not interact with each other. In a gravitational interaction, the two dipolar preons that exchange a boson attract each other, irrespective of their signs.

## 2. Origin

A dipolar preon can emit the two charges it carries together with their anticharges. It does this by borrowing the appropriate charge-anticharge pairs from the vacuum. The emitting dipolar preon will be left unchanged, carrying its original charges. The two emitted charge-anticharge pairs together constitute a virtual boson that transmits the gravitational force. This boson is called the **dp-boson** (dp stands for dipolar preon), and it has no net electric charge. It is not composed of preons, and is thus massless. In consequence, it can be emitted away from the elementary fermion in which the emitting dipolar preon is located.

Example: ND1 preon  $\Rightarrow$  dp-boson $[E1-1/2][E2+1/2][E1+1/2][E2-1/2]$ .

Boson notation: The elementary charges identical to those of the emitting preon are written first. These are called *leading charges*, and they are the charges that interact with the charges on the dipolar preon that will absorb the boson.

The dp-boson is preon-group specific. So, there are obviously three different dp-bosons, one per preon group. In the example above, the dp-boson emitted by an ND1 preon can be absorbed only by another ND1 preon (resulting in attraction) or by a PD1 preon (also resulting in attraction). In either case, the absorbing preon is located in an elementary fermion separate from the one in which the emitting preon is located.

In the example above, suppose the dp-boson emitted by an ND1 preon is absorbed by a PD1 preon. The leading charges of the dp-boson are of mixed sign, ie. one is negative and one is positive. So, when the boson collides with the absorbing PD1 preon, the boson's charges will interact with the preon's two charges, which are also of mixed sign. The result will be attraction. If the boson is absorbed by another ND1 preon, the situation is the same.

The dp-boson is always a virtual boson, and cannot be observed as a real particle.

## 3. Gravitational interaction

Any two dipolar preons belonging to the same preon group, located in separate elementary fermions, can interact together by exchanging a dp-boson. The boson will transmit the gravitational force. A gravitational interaction causes the two interacting dipolar preons to attract each other. The interaction does not alter preon charges. So, all dipolar preons belonging to the same preon group will attract each other, in whichever fermion they are located. Note that there are three separate streams of interactions between dipolar preons, one for each preon group.

Two constituent dipolar preons inside an elementary fermion (neutrino or D-quark) do not attract each other. This is because a dp-boson cannot be exchanged between dipolar preons belonging to two different preon groups.

Inside a neutron, there are three dipolar preons belonging to the same preon group. Two are of negative sign, and are found one in each of the two D-quarks. The remaining dipolar preon is of positive sign, and is found in the

U-quark. These three preons attract each other. But the effect is negligible because the gravitational force is extremely weak.

#### 4. Mass and gravity

Since dipolar preons are found almost exclusively in the neutrons and protons making up atomic nuclei, it is observed that bulk matter gravitates. But it is not mass that is the source of gravity.

The **graviton** is not the transmitter of the gravitational force between two dipolar preons. A graviton is always a real particle/wave, and its job is to transfer energy and angular momentum between fermions.

A graviton is emitted when an electrically-neutral particle in the singlet state is accelerated. These particles contain dipolar preons (which are thus accelerated). Only neutrons and neutrinos (and their antiparticles) emit gravitons. Due to the extreme weakness of the gravitational force, gravitons are undetectable.

How does a neutron emit a graviton? What happens is that each of the three dipolar preons of same sign (in different quarks) emits the dp-boson specific to its preon group. The three different dp-bosons then aggregate together to form a real graviton.

When a graviton is absorbed by a neutron, each dp-boson is absorbed by the appropriate dipolar preon according to its preon group. Emission/absorption of a graviton causes changes in the angular momentum of an electrically-neutral particle in singlet form. The effect of a graviton on one particle is so weak that it is undetectable. When a large mass (eg. star) containing a multitude of dipolar preons is accelerated, it emits a gravitational wave (consisting presumably of a multitude of gravitons).

## Matter-Antimatter Asymmetry

According to this preon model, the Universe contains both matter and antimatter. We define matter as the preons of positive sign, and antimatter as the preons of negative sign. It seems likely that the Universe contains equal numbers of positive and negative preons, and has zero net electric charge for each electric species.

The observable material Universe likely contains electrons, protons, neutrons, and electron neutrinos in equal numbers.

Starting from two sets of the twelve different preons, we can construct an electron, a proton and a neutron of same isomeric form, and an electron neutrino. In the table below, the proton and neutron are of isomeric form C.

| <b>Particles Constructed From Two Preon Sets</b> |                |                |                |
|--|----------------|----------------|----------------|
| <b>Fermion</b>                                   | <b>Group A</b> | <b>Group B</b> | <b>Group C</b> |
| <b>Electron</b>                                  | <b>NE1</b>     | <b>NE2</b>     | <b>NE3</b>     |
| <b>Proton(C) - PosU(A) quark</b>                 | <b>PD1</b>     | <b>PE2</b>     | <b>PE3</b>     |
| <b>Proton(C) - PosU(B) quark</b>                 | <b>PE1</b>     | <b>PD2</b>     | <b>PE3</b>     |
| <b>Proton(C) - NegD(C) quark</b>                 | <b>ND1</b>     | <b>ND2</b>     | <b>NE3</b>     |
| <b>Neutron(C) - NegD(A) quark</b>                | <b>NE1</b>     | <b>ND2</b>     | <b>ND3</b>     |
| <b>Neutron(C) - NegD(B) quark</b>                | <b>ND1</b>     | <b>NE2</b>     | <b>ND3</b>     |
| <b>Neutron(C) - PosU(C) quark</b>                | <b>PE1</b>     | <b>PE2</b>     | <b>PD3</b>     |
| <b>Electron Neutrino</b>                         | <b>PD1</b>     | <b>PD2</b>     | <b>PD3</b>     |

From the table we see that there are twelve electric preons and twelve dipolar preons. The three preon groups are equally represented. Annihilation of a preon with its antipreon is impossible, as they are segregated in different fermions.

Using the same 24 preons as above, we can also construct the antiparticles of the four fermions mentioned above, ie. a positron, an antiproton and an antineutron of same isomeric form, and an electron antineutrino.

The mystery is why these latter particles are not observed.

Maybe, in the early universe, enormous amounts of both the above-mentioned sets of particles were created. These two sets would annihilate each other. But if there were a slight imbalance in favour of one of the two sets, after annihilation only particles of that set would remain as observable 'matter'. We have called these material particles electron, proton, neutron, and electron neutrino.

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