Bosons in the Zoo of Elementary Particles

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Abstract

In this paper we want to raise the question concerning the physical identity of bosons and the function that they perform in the Non-Standard Model. Specifically we will analyse the physical nature and the physical behavior of both intermediate vector bosons (particles W and Z) and the Higgs boson, reaching different interpretations with respect to standard those. We will examine then the question on the stability of atomic nuclei and on the role of the gluon-boson.

1. Introduction

In the Standard Model bosons are elementary particles which have integer spin (including zero spin), unlike fermions which are elementary particles that have semi-integer spin. This definition isn' t valid in the Non-Standard Model where bosons are typified by exclusively zero spin while fermions have a different from zero spin and therefore also integer besides semi-integer[1][2]. As per this definition in the NSM all charged elementary particles are fermions while neutral particles are bosons. In the SM all mesons are considered bosons; in the NSM only neutral mesons are bosons while charged mesons are fermions. From this viewpoint also baryons Δ ($\Delta^+, \Delta^-, \Delta^o, \Delta^{++}$) are very interesting: in fact in the SM they have the same semi-integer spin 3ħ/2 and therefore are fermions. In the NSM instead they have different spin according to their electric charge: Δ^+ has spin +ħ/2, Δ^- has spin −ħ/2, Δ^o has zero spin and Δ^{++} has spin +ħ. Therefore in the NSM only Δ^+, Δ^- and Δ^{++} are fermions while Δ^o is boson.

Also particles W and Z are very interesting: in the SM they are considered bosons and are responsible for the electroweak force. We will see in this paper that in the NSM these particles have completely different physical properties and only the neutral particle Z^o is actually boson.

At last the Higgs boson, whose empirical trial has been confirmed recently in CERN laboratories (ATLAS and CMS experiments), has a peculiar role in the SM, where this particle, as per the Higgs mechanism, would be the main cause of the "symmetry breakage" that would allow the unification of e.m. force and weak force only at high energies and at small distances; in addition it would give mass to all other particles. We will see in the NSM the Higgs boson has a different meaning.

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2. General properties of bosons

Main physical properties of bosons in the Standard Model are:

1. Bosons have integer spin, including zero spin.
2. They don’ t respect Pauli’ s Exclusion Principle (that claims one quantum state can be occupied only by one particle). In fact many different bosons can occupy the same quantum state as photons in the light. That principle instead is respected by fermions.
3. They follow Bose-Einstein’ s statistics while fermions follow Fermi-Dirac’ s statistics.
4. Bosons differ in:
   a. intermediate vector bosons (gauge bosons): photons, gluons and weak bosons (particles W and Z)
   b. mesons.
5. Gauge bosons are intermediate particles and they are considered responsible for fundamental forces:
   a. The electromagnetic force is mediated by photons (spin 1, zero mass)
   b. The weak nuclear force is mediated by bosons W and Z (spin 1, W’ s resting mass is about 80 GeV/c^2, Z’ s resting mass is about 91 GeV/c^2).
   c. The strong nuclear force is mediated by gluons which have spin 1 and zero electric charge, (mass is controversial).
   d. The gravitational force would have to be mediated by gravitons, which are bosons with spin 2, zero electric charge and zero resting mass.

The unification of both the electromagnetic force and the weak nuclear force through the Theory of the Electroweak Force (by S.L. Glashow, S. Weinberg, A. Salam) had to overcome the great obstacle about the range of the two forces, which is smallest for the weak nuclear force and greatest (practically infinite) for the electromagnetic force. This contradiction has been surmounted taking on that for smallest distance and for highest energies the two forces are equal as per a symmetry principle, while for greatest distances only the electromagnetic force acts. In the SM gauge bosons are responsible for fundamental forces but we will prove in the NSM bosons perform other functions. Photon for example is considered the responsible and intermediate particle for the electromagnetic force, but we know, specifically by Maxwell’ s equations, photon is an effect of the electromagnetic force, as it happens for instance inside atom when an electron jumps from an energy level to the other or in the acceleration of a charged particle that emits energy quanta with greater frequency than light quanta. Similarly intermediate vector bosons (particles W and Z) are considered responsible for the weak force but we will prove particles W are leptons and only the particle Z is actually boson.

3. Properties and classification of bosons in the Non-Standard Model

As per our studies presented in preceding papers[2][3][4] bosons have in the Non-Standard Model the following physical properties:

1. Bosons have always zero electric charge.
2. Consequently as per the relationship between charge and spin[1][2][3] (we call it here "Theorem of Charge and Spin") they have always zero spin.
3. Bosons have positive or zero electrodynamic mass.
4. In the NSM bosons respect the properties 2. and 3. which are valid also in the SM.
5. Bosons aren' t always cause or intermediation of fundamental forces and very often perform other functions.
6. Bosons in the Non-Standard Model differ in:
   a. Energy bosons
   b. Massive bosons

Energy bosons have electromagnetic nature and coincide with energy quanta which respect Planck' s relation (E=hf). They are physically electromagnetic nanowaves[5] and are described mathematically by "photon equations".
They occupe the frequency spectrum from the infrared radiation ($f=3 \times 10^{11}$Hz) to δ–Y radiation ($f>1{,}13 \times 10^{23}$Hz). Energy bosons are stable particles, have always zero electric charge and zero spin. All neutrinos, of any provenance, are energy bosons. Energy bosons are the effect of the electromagnetic force when they have atomic nature, like for example infrared, light, ultraviolet and X rays. Energy bosons are instead the effect of the decay of unstable particles in the event of gamma, delta and delta-Y rays.
Massive bosons have electrodynamic nature and belong whether to leptonic family or to baryonic family, but anyway they have zero electric charge and zero spin. Massive bosons belong to the positronium subfamily if their physical nature is leptonic and belong to the neutron subfamily if their physical nature is baryonic. Unlike energy bosons, massive bosons are unstable and decay spontaneously according to decay typical processes of both positronium and neutron.
In the order of the Non-Standard Model bosons have a well precise role inside the zoo of elementary particles; we represent here in fig.1 a new scheme of classification of all known elementary particles.

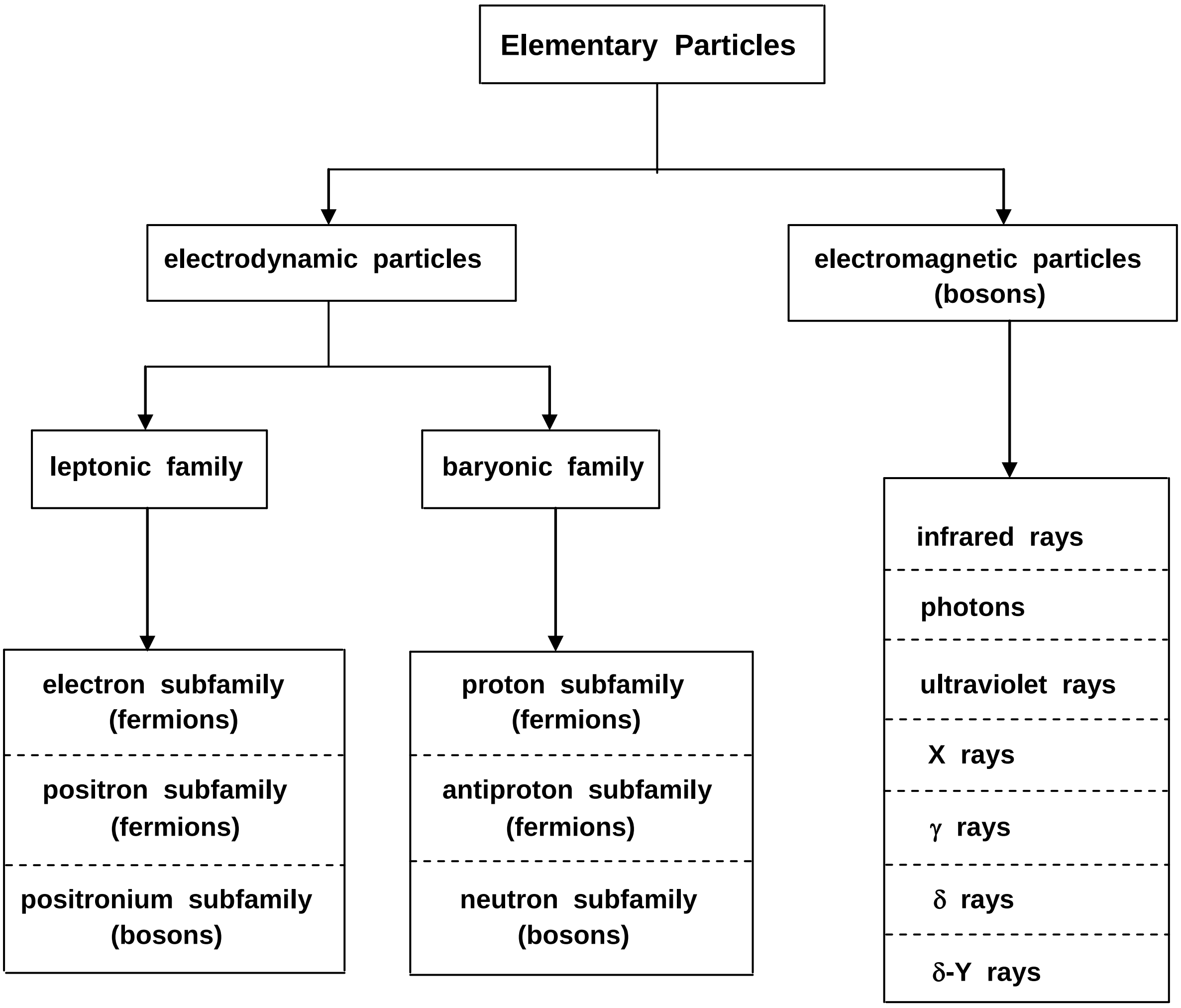

Fig.1 Scheme of classification of elementary particles in the Non-Standard Model.

4. Intermediate vector bosons in the Non-Standard Model

In SM intermediate vector bosons (particles W^+, W^-, Z^o) are considered the responsible intermediaries for the weak nuclear force while photon is responsible for the electromagnetic force.

The theory of the electroweak force is a gauge theory that represents the unification of both the electromagnetic force and the weak nuclear force as per a symmetry principle, which nevertheless is valid only at highest energies and at smallest distances.

The asymmetry of the two forces (that have very different ranges) was surmounted taking on that the two forces are equal only for smallest distance ($<10^{-16}$cm) while for greater distances only the electromagnetic force acts because it has a practically infinite range.

In the same model (SM) bosons W, which have a different from zero electric charge, work in the weak interactions in which the electric charge changes, as for example the neutron decay, while the boson Z is the neutral particle that works in the weak interactions (called “processes with neutral current”) in which the electric charge doesn’ t change. Moreover the different range is explained taking on that it is inversely proportional to mass: zero mass for photon (intermediary of the electromagnetic force) and greatest mass for intermediate vector bosons (intermediaries of the weak force). The breakage of the gauge symmetry at small energies and at great distances is caused in SM by the Higgs boson.

Let us tackle now the question on the physical nature of intermediate vector bosons in the order of the Non-Standard Model.

The three intermediate bosons have been observed indirectly in collision processes; they are unstable, have shortest average life (about 10^{-24}s) and therefore decay immediately. The particles $W^{\pm}$ decay generally in one lepton and one neutrino or in a pair quark-antiquark, while the particle Z^{o} decays in a pair lepton-antilepton.

As regards the decay of particles $W^{\pm}$ to a pair quark-antiquark, which is the structure of mesons in the quark model, we remind that in the NSM mesons are unstable leptons[2] and therefore in the NSM the two cited processes of decay of particles $W^{\pm}$ coincide. As per the Decay Principle[2] the particles $W^{\pm}$ belong to the leptonic family and aren' t bosons because they have different from zero both electric charge and spin. In particular W^- has electric charge −1 and spin $-\hbar/2$ while W^+ has electric charge +1 and spin $+\hbar/2$. For the particles $W^{\pm}$ the following end processes of decay are valid, also when intermediate decays can happen,

$$\begin{aligned} W^+ &\longrightarrow e^+ + \delta_w \\ W^- &\longrightarrow e^- + \delta_w \end{aligned} \tag{1}$$

where δ_w represents the neutrino of particles $W^{\pm}$. Assuming for the two particles W a negative electrodynamic mass equal to $-80{,}4\mathrm{GeV}/c^2$ because of their instability and their leptonic electric charge, the neutrino δ_w has a frequency $f_w = 19{,}4 \times 10^{24}$Hz. The neutrino δ_w belongs to the hard under-band δ-Y.

In the NSM the particles $W^{\pm}$ can represent the intermediate particles in the decay processes of both the neutron at high energy and the antineutron at high energy. The decay processes of both at small energy , the slow neutron and the slow antineutron, have been studied in a preceding paper[6] and in that case there is no need for intermediate particles. The decay instead of the neutron at high energy can be described by the following group of processes

$$\begin{aligned} n &\longrightarrow p^+ + W^- \\ W^- &\longrightarrow e^- + \delta_w \end{aligned} \tag{2}$$

in which the particle W^- represents the intermediate particle of the decay.

For the antineutron $\underline{n}$ at high energy the following processes of decay are valid

$$\begin{aligned} \underline{n} &\longrightarrow p^- + W^+ \\ W^+ &\longrightarrow e^+ + \delta_w \end{aligned} \tag{3}$$

in which now the particle W^+ represents the intermediate particle.

For the particle neutral Z^o instead the most probable processes of decay are

$$Z^o \longrightarrow e^- + e^+ + \delta_{eZ}{}^o \qquad (4)$$
$$Z^o \longrightarrow \delta_Z{}^o + \delta_Z{}^o$$

that are the typical processes of decay of neutral positronium[2].
Assuming for Z^o a positive mass equal to 91,2GeV/c^2, the neutrinos $\delta_{eZ}{}^o$ and $\delta_Z{}^o$ have a practically equal frequency $f_{\delta eZ}{}^o \approx f_{\delta Z}{}^o = 22 \times 10^{24}$Hz, which belongs to the under-band delta-Y.
The particle Z^o, unlike particles W, is really a boson also in the NSM, because it has zero electric charge, zero spin and a positive electrodynamic mass. Also in the decay process of the particle Z^o intermediate processes of decay are possible with the production for instance of muons, but anyway end products are the same.
In the NSM particles $W^\pm$ and Z^o aren' t the intermediate particles of the electroweak force, but W^+ and W^- are the intermediate particles in the decay process of both neutron at high energy and antineutron at high energy, while Z^o is a strongly unstable shape of positronium.

5. The Higgs boson in the Non-Standard Model

In SM the Higgs boson has an exclusive role: it is considered the fundamental particle that gives mass to all other particles through the Higgs mechanism.
According to this mechanism on the big-bang the Higgs field was born and all generated elementary particles were without mass. The Higgs boson, which is the intermediate particle of the Higgs field, gave mass to all massive particles as a consequence of the interaction force between particles and field: the more this force is great the more the mass given to particle is great. The Higgs field is also the base for the unification of both, the electromagnetic force and the weak nuclear force, in the electroweak force for high energies and small distances where a symmetry principle is valid for the two considered forces. The Higg boson would be also the cause of the breakage of this symmetry at small energies and at great distances.
In the Non-Standard Model, according to experimental data, we can assume for the Higgs boson B_H the following physical properties:

a. B_H is an unstable particle
b. It has zero electric charge and zero spin and therefore it is a boson
c. The observed decay channels for the Higgs boson, through decay end products, are largely two:
    1. channel with two energy quanta
    2. channel with four leptons

d. The boson B_H has a highest value of mass that recent experiments ATLAS and CMS at CERN (proton collisions) have fixed around $125GeV/c^2$ with small differences between the two cited experiments: $126{,}6GeV/c^2$ for the decay process with two energy quanta and $123{,}5GeV/c^2$ for the decay process with four leptons.

The boson decay through the first channel has smaller probability to be observed and it happens according to the following process

$$B_H \longrightarrow \delta_H + \delta_H \qquad (5)$$

Assuming for the boson B_H the mass $126{,}6GeV/c^2$, each energy quantum has a frequency

$$f = \frac{126{,}6 \times 10^9 \times 1{,}6 \times 10^{-19}}{2 \times 6{,}63 \times 10^{-34}} = 15{,}3 \times 10^{24} \text{ Hz} \qquad (6)$$

for which we deduce the two quanta belong to the band δ-Y.
The boson decay through the second channel has greater probability to be observed and it happens according to a multiple process in which two bosons Z^o are the product of a decay intermediate process

$$B_H \longrightarrow Z^o + Z^o \qquad (7)$$

and later each particle Z^o decays to two leptons according to the following processes

$$\begin{aligned} Z^o &\longrightarrow e^- + e^+ + \delta_{eZ}{}^o \\ Z^o &\longrightarrow \mu^- + \mu^+ + \delta_{\mu Z}{}^o \\ Z^o &\longrightarrow \tau^- + \tau^+ + \delta_{\tau Z}{}^o \end{aligned} \qquad (8)$$

in which neutrinos concerning the three different decay processes of the particle Z^o have respectively frequencies

$$\begin{aligned} f_{\delta eZ}{}^o &= 22 \times 10^{24} Hz \\ f_{\delta \mu Z}{}^o &= 21{,}96 \times 10^{24} Hz \\ f_{\delta \tau Z}{}^o &= 21{,}15 \times 10^{24} Hz \end{aligned} \qquad (9)$$

Anyway Z^o intermediate decays to leptons μ or to leptons τ involve the succeeding decay of these unstable particles to electrons or positrons.
From the study of decay channels of the Higgs boson we can deduce, as per the Principle of Decay[2], that it represents an unstable state, at highest energy, of positronium, and belonging therefore to the positronium subfamily and to the family of leptonic particles (fig.1). As per our conclusions we can claim Z^o represents an intermediate particle in the decay process of the Higgs boson.

6. The gluon and the stability of atomic nuclei

In SM the gluon is a boson that has the following physical properties:

a. Zero electric charge
b. Spin =1
c. Zero theoretical mass (some experimental results give different from zero mass.

Also in the NSM gluon is a boson, but its spin is zero because of its zero electric charge as per the "Theorem of Charge and Spin" . The disagreement between theoretical mass and a few experimental results doesn’ t allow to claim certainly if it is an energy or massive boson.

In the quark structure of the SM gluon is responsible for the strong nuclear force which gives stability to atomic nuclei.

Let us analyse now the stability of atomic nuclei in the order of the Non-Standard Model. The nucleus of hydrogen is composed of one single proton and therefore the stability of this nucleus is connected with the proton stability. Nuclei of all other chemical elements are composed of protons and neutrons and therefore necessarily the proton-neutron bond gives stability to nucleus.

Since we know neutron is composed of one proton and one electron we can deduce in the NSM that the proton-neutron bond is actually a bond between two protons through one exchange nuclear electron which moves around the two protons with greater than light speed[7], at least equal to the critical speed (fig.2). In this model there is a continuous exchange of the nuclear electron between the two protons for which each time one of the two protons behaves like a neutron and this continuous exchange allows the two protons to overcome the repulsive electrostatic force.

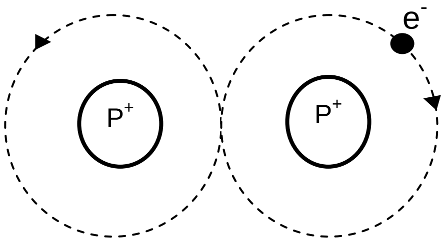

Fig. 2 Proton-neutron bond with the exchange nuclear electron.

The experimental mass of the structure proton-neutron, which represents the deuteron, is equal to 2,01418 u.f.m. (1u.f.m.=931MeV) that are equivalent to 1875,2MeV/c^2. The proton has mass= 938,07 MeV/c^2 while the neutron has mass=939,36 MeV/c^2. The deuteron mass is smaller than the total mass of proton and neutron and the mass defect is 2,23 MeV/c^2 that represents the binding energy of deuteron:

$$\text{deuteron + binding energy = proton + neutron} \qquad (10)$$

The proton-neutron bond is a very stable nuclear bond characterized by a binding energy of 2,23 MeV that holds protons and neutrons together inside the nucleus through the exchange nuclear electron. Therefore in the NSM the exchange particle which generates the strong nuclear force is the exchange electron which has characteristics different from the gluon and above all it isn' t a boson.

If a proton-neutron bond is supplied with an external energy, at least equal to the binding energy, for instance by bombardment or collision with suitable projectiles (alpha particles, deuterons, γ quanta), the bond can break and one neutron is emitted by nucleus. The emitted neutron is unstable and outside nucleus undergoes a spontaneous process of decay that has been described in a preceding paper[6].

The same nuclear bond can be obtained also through the bond between one proton and one antineutron (fig.3): this bond is certainly existing in artificial radionuclides.

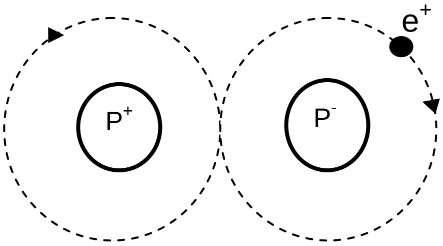

Fig. 3 Proton-antineutron bond with the exchange positron.

The conventional electric charge of this bond is still +1 like in the bond proton-neutron; also the nuclear positron, like the nuclear electron, has in this bond the function of exchange particle. Moreover in that case an attractive electrostatic force, instead of repulsive, acts between proton and antiproton and the strong nuclear force due to the exchange positron allows to overcome the attractive electrostatic force and to give stability to the bond.

The spontaneous breakage of the proton-antineutron bond is the cause of the positive beta emission in artificial radionuclides, as the spontaneous breakage of the proton-neutron bond is the cause of the negative beta emission in natural radionuclides.

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