SU(2)$_L$ x SU(2)$_R$ SYMMETRY OF THE FERMIONS AND THE VECTOR BOSONS, THE FERMIONIC ORIGIN OF THE LOCAL GAUGE TRANSFORMATIONS, THE VISIBLE TRACES OF THE FLICKERING NATURE OF THE EARLY STAGES OF THE UNIVERSE'S FORMATION

FIZULI AGAMUSA MAMEDOV
Institute for Physical Problems, Baku State University, Azerbaijan
e-mail: mail.quanta02@gmail.com, phone: (994) 12 510 18 22

The vector boson wave functions are built by combining the fermion wave functions, coupling constants, partial derivatives and the generators of the symmetry groups which these vector bosons are associated with. This representation of the gauge bosons allows one to explain a wide range of the facts relating to the elementary particles in a natural and simple form. The visible traces of the flickering nature of the early stages processes in the universe, usually called Big Bang processes, in the nuclear scale properties of the chemical elements is also discussed..

The possible original SU(2)$_L$ H SU(2)$_R$ symmetry of the fermions allows us to consider the electroweak interaction bosons **W**: and *B*: as the fused states of the fermions [5].

There are two sets of the vector bosons in this model, (**W**:)$_L$, (*B*:)$_L$ and (**W**:)$_R$, (*B*:)$_R$, belonging to the domains of the left - handed fermions and right - handed fermions, respectively. The coupling of the (*B*:)$_L$ to the right - handed fermions breaks the SU(2)$_L$ H SU(2)$_R$ symmetry.

The assumption of the proportionality of the electroweak vector bosons' masses to their corresponding coupling strengths[1] leads to the customary definition of the Z boson and to the well - known M$_W$ - M$_Z$ mass relation [5].. In this work we build the wave functions of the vector bosons by combining the fermion wave functions (the complex Dirac fields) R(x), the coupling constants, the generators of the corresponding symmetry groups of these vector bosons and the partial derivatives M:, which recover the Lorentz indices of the vector boson wave functions. In the case of the B:, the symmetry group is U(1) which has the unit matrix as its only generator. Therefore the ingredients of the normalized *B*: wave function will be R(x), the coupling constant gr and M::

$$Mw/M_B = g/gN \qquad (1)$$

$$B{:}(x) = R^+(x)(i/gr)M{:}R(x)/(R^+(x)R(x)) \qquad (2)$$

The local gauge transformations exp{-*i*7(x)) of R(x) produce the familiar gauge transformations for the *B*:(x):

$$B{:}(x)\ 6\ R^+(x)\exp\{i7(x))\ (i/gr)M{:}\exp\{-i7(x))\ R(x)/R^+(x)R(x)) =$$

$$R^+(x)(i/gr)(M{:} - i\ M{:}(x))\ R(x)/(R^+(x)R(x)) = B{:}(x) + M{:}(x)/gr$$

$$B{:}(x)\ 6\ B{:}(x) + M{:}(x)/gr \qquad (3)$$

The triplet of the vector bosons **W**: can be represented as

$$(W_l){:} = R^+(x)F_i(2i/g)M{:}R(x)/(R^+(x)R(x)) \qquad (4)$$

Here R(x) is the fermion, spinor doublet and F$_i$ are Pauli matrices.

As we will see in the following discussion the non - Abelian infinitesimal gauge transformations of the fermion doublets

$$R(x)\ 6 \quad \exp\{-iF_i7_i(x)/2)R(x) \qquad (5)$$

indeed generate the local gauge transformations for the vector bosons **W**:. The phase shift for the R(x), Eq. (5) induces the following transformation for the vector boson field:

$$(W_l){:}\ 6\ R^+(x)\exp\{iF_i7_i(x)/2)F_l(2i/g)M{:}\exp\{-iF_i7_i(x)/2)\ R(x)/(R^+(x)R(x)) =$$

$$R^+(x)\exp\{iF_i7_i(x)/2)F_l[(2i/g)M{:} + (1/g)F_iM{:}7_i(x)]\exp\{-iF_i7_i(x)/2)R(x)/(R^+(x)R(x))$$

131, H.Javid ave, AZ-1143, Baku
Institute of Physics
E-mail: jophphysics@gmail.com

The two terms in this equation correspond to the (W_l): $+(7(x)H\mathbf{W}:(x))_l$ and $M:7_l(x)/g$ terms of the local gauge transformations of (W_l):, respectively. For the former term, because of the infinitesimally small values of $7_i(x)$,

$$F_l \exp\{-iF_i 7_i(x)/2) = F_l (1 - iF_i 7_i(x)/2) = F_l - i(F_i F_l + 2i\, g_{lik} F_k) 7i(x)/2 = (1- iF_i\, 7i(x))F_l + i\, g_{lik} 7i(x) F_k =$$

$$(1 - iF_i 7_i(x)/2)F_l + g_{ikl} 7i(x) F_k = \exp\{-iF_i 7_i(x)/2)F_l + (7(x)H\, F)_l = \exp\{-iF_i 7_i(x)/2)(F_l + (7(x)H\, F)_l)$$

In the last line we took into account that these calculations are done up to the first order only in $7i(x)$. Similarly, because of the infinitesimal nature of the gauge transformations typically considered, in the term with the derivative of the $7i(x)$, $\exp\{-iF_i 7_i(x)/2)$ can be readily taken to the left side of F_i up to the first order in $7i(x)$ calculations and for the product $F_l F_i$ we use the anti commutation property of the Pauli matrices and take into account that both l and i are dummy indices at the scale of Lagrangian or cross section expressions:

$$(1/g)F_l F_i\, M:7_i(x)\ 6\ (1/(2g))(F_l F_i + F_i F_l)\, M:7_i(x) = M:7_l(x)/g$$

We can describe this transition procedure more explicitly as follows: $F_l F_i$ is sandwiched between $\sim_L$ and $\sim_R$ structures in the cross section expressions and by using the anticommutation relations for the Pauli matrices we can write

$$\sim_L F_l F_i \sim_R\ =\ -\sim_L F_i F_l \sim_R + 2 \sim_L *_{li} I \sim_R \quad 6\ \sim_L F_l F_i \sim_R + \sim_L F_i F_l \sim_R = 2 \sim_L *_{li} I \sim_R$$

The two terms on the left hand of side of the second equation are equal because l and i are dummy indices. Therefore

$$\sim_L F_l F_i \sim_R\ =\ \sim_L *_{li} I \sim_R$$

In summary as a result of the gauge transformation of the second kind the vector field W^l: undergoes the transformation essentially the same as the well familiar transformation of the electroweak vector boson[1]

$$W^l{:}\ 6\ W^l{:} + (7(x)H\mathbf{W}{:}(x))^l + M{:}7^l(x)/g \qquad (6)$$

If we add a leptonic hypercharge factor Y = -1 to the argument of the exponent in the gauge transformation, $\exp\{-iF_i 7_i(x)/2)$ 6 $\exp\{-iYF_i 7_i(x)/2)$, we will get the second and the third terms in Eq. (6) for the gauge transformation with minus sign. This is good enough for the field strength W:< to transform like a vector under the gauge transformations. We can argue that these fused state fermions do not act in the ordinary space - time. Here we are talking about Planck distance scale processes.Z: and A: fields themselves are formed by adding up two fields, multiplied by the coupling constants (Eq.(10) and Eq.(11) in this paper). One can consider the phase factor 7(x) (its derivative more precisely) inducing the gauge transformations also as some type of field created due to the formation of the ordinary space - time. The ingredients of the electromagnetic field, the electric field E and the magnetic field **B** are also different forms of derivatives of the electr:omagnetic four - potential A:.

The structure of the *B*:, Eq.(2) and W:, Eq.(4) fields is close to partial derivative M: of lnR(x) sandwiched by $R^+(x)$. It is natural to expect that the structure lnR(x) will reveal smaller experimental fluctuations than the fermion field R(x) itself. So one must expect smaller standard deviation factor in the vector boson related data according to its Eq.(4) structure. One would say that vector bosons are more 'comfortable' (more aware of movement) along the space - time trajectory than fermions. This more awareness feature of bosons makes them also a good choice as the interaction intermediaries. The Pauli's exclusion principle could well be the consequence of this difference of fermions from bosons. Gauge transformations formula for bosons consist of two parts, quantum mechanical part and essentially classical part, M: Denominators in Eq. (2) and Eq. (4) take off most of the quantum mechanical nature of gauge bosons and this may well lead to the quantum mechanical part plus classical mechanical part type of formula. One could conduct Bohm - Aharonov effect type of experiment to see if the gauge transformations of the gauge bosons lead to the change in the interference pattern. Instead of two electron beams two photon beams should be used here naturally.The challenge here is to make the medium between the slits and the interference patterns detection screen as non - uniform as possible to induce large enough value for $M:7_i(x)$. At CERN photon - photon interactions are often studied via ultraperipheral collisions (UPCs) of heavy ions, such as gold or lead [8]. Part of theinteraction effect could well come from the highly non - uniform environment created in these experiments. PVLAS experiments conducted there strongly support the presence of new physics in the domain of these experiments, typically ascribed to the existence of axions.

[1] We wrote the vector field in a contravariant form here for the sake of brevity of notations and for its more customary look

A few words about the Lorentz covariance aspect of the boson field structures in Eq.(2) and Eq.(4) discussed earlier. After the gauge transformation we have gotten two component and three component expressions, Eq.(3) and Eq.(6). Each term in these expressions is Lorentz covariant to the four - dimensional vector. This is most visible in the last component, in the M:7(x) term, in these expressions. This component is the simplest form of four - dimensional vector. Eq.(2) and Eq.(4} forms for gauge bosons could also be a good starting point to bring together quantum mechanics and the theory of relativity. The right - hand side of these equations is built of quantities inducing 'spooky action at a distance' (A. Einstein), but the quantities in the left - hand side, the gauge bosons are unlikely to induce 'spooky action at a distance'. Fractional form of these equations trims part of the quantum mechanics nature of wave functions.

The phase shift factor 7(x) of the gauge boson fields defined by the Eq.(2) and Eq.(4) reveals their important space - time related property. It is the presence of this phase shift that gives the four - dimensional vector M:7(x) in the explicit form (Eq.(3) and Eq.(6). So in order for the *B*: and (W_l): fields defined by Eq.(2) and Eq. (4) to be Lorentz - covariant to the customary four - dimensional boson fields the phase shift has to be present all the time. In other words, the fields with this type of structure always have to move in non - uniform space - time environment, all the gauge boson intermediaries should be in the condition of constant motion. Metaphorically speaking, we cannot get a cup of bosons in the lab which makes them different from the fermions. Therefore to be the interaction intermediaries is their chance to exist. Fermions and gauge bosons can be considered as complementary physical quantities to some extent, fermions shape the the space - time (the universe), through their masses, the masses of the atomic nuclei and electrons mainly. The gauge bosons from the other side create interactions among the elementary particles by traveling through this space - time. This approach to understanding the properties of massive gauge bosons brings them one step closer to photons. Here we have another question. Are the photons indeed massless? The energy - mass elation formula

$$E = m_0c^2//\{1 - v^2/c^2\} \quad (7)$$

does not forbid the existence of massive photons. By squeezing m_0 6 0 and v 6 c we can still get a finite photon energy. It is true that after the certain value of the photon mass we will encounter the quantum fluctuations aspect of this procedure. We also see the parallelism of energy - mass formula to the boson structure formulas discussed above: we can talk about the photon energy within the realm of the partial derivatives (their ratios) only. Moving from the Heisenberg's uncertainty principle objects, the wave functions R(x) to the structures with the partial derivatives by itself is an indication to the shift to the Lorentz - invariance world, we can have consistent equations with derivatives, with infinitesimally small quantities present, in the Lorentz -covariance, Lorentz - invariance world only.

In the frame of the currently used models for the elementary particles, there is a noticeable disarray of the values for thehypercharge of particles, the particles' coupling intensity indicator to the most fundamental field. It is natural to expect that at the most fundamental level hypercharges of particles are distributed according to the definite type of symmetry. $SU(2)_L$ H $SU(2)_R$ symmetry model of bosons discussed in [5] brings significant clarity to this situation. The scalar doublet introduced in the Standard Model leaves the hypercharges of particles unchanged, the spontaneous symmetry breaking process does not affect quantum numbers of elementary particles. The fermion fusion model approach does not have an explicit Lorentz - invariance violation problem too in the shift in the symmetry process.

We have already told earlier that it is most likely that the fermion - vector boson couplings appear after the shift in the symmetry. In terms of the Lagrangian, this means replacement of the Lie derivative M: by the covariant derivative *D*:. Interestingly, the replacement of M: by *D*: has no significant effect on the definitions of the *B*: field:

$$B{:}(x) = R^+(x)(i/gr)D{:}R(x)/(R^+(x)R(x)) = R^+(x)(i/gr)(M{:} + igrB{:}(x))R(x)/(R^+(x)R(x)) =$$

$$-B{:}(x) + B^o{:}(x)$$

Or

$$B{:}(x) = B^o{:}(x)/2 \quad (8)$$

Here B^o:(x) is the *B*:(x) field defined through M: only. We can interpret this twice smaller value of the *B*:(x) field as follows: the emergence of the covariant derivative factor mitigates the shift in the symmetry process.
For the vector boson W:(x)

$$(W_l){:} = R^+(x)F_l(2i/g)D{:}R(x)/(R^+(x)R(x)) = R^+(x)F_l(2i/g)(M{:} - iF_i/2(W_i){:})(x)/(R^+(x)R(x)) =$$

$$(W_l)^0{:} + (1/g)R^+(x)F_lF_i/2(W_i){:}(x)/(R^+(x)R(x)) \;\; 6 \;\; (W_l)^0{:} + (1/2g)R^+(x)(F_lF_i + F_iF_l)(W_i){:}(x)/(R^+(x)R(x)) =$$

$$(W_l)^0{:} + (1/g)(W_l){:}$$

$$(1 - 1/g)(W_l){:} = (W_l)^0{:} \;\text{ or }\; (W_l){:} = (W_l)^0{:} /(1 - 1/g) \quad (9)$$

Eq.(10) tells us that in reality the (W_l): field might have a slightly more complex structure than described by Eq.(4) (compare Eq.(9} and Eq.(10)..The replacement of the M: by the *D*: does not change the field strength *B*:< for the *B*: field. For the triplet of vector boson (W_l): this leads to the emergence of the self - coupling term in the F:<:

$$F^i{:<} \; = M{:}(W^i){<} \; - M{<}(W^i){<} - gg^{ijk}\,(W^j){:}(W^k){<}$$

This essentially familiar difference between these two fields resonates well with the $I_W = 0$ nature of the *B*:.field. Its interactions with the other particles occurs at the more fundamental level.

The replacement of the derivatives M: by the covariant derivatives *D*:, the emergence of the interactions among the particles, is the result of the appearance of the 'curvedness' in the space - time after the shift in the symmetry. Different points of the space - time are no longer equal for the wave functions R(x), grY*B*: and $g(W_l){:})F_i/2$ are the measures of this difference of the points of the space - time. Interestingly, the mass terms for the vector bosons, $M_B{}^2 BlB^l$ and $M_W{}^2 \mathbf{W}l\mathbf{W}^l/2$ are Lorentz invariants built out of the measure of the 'curvedness' of the space - time, gr*B*: and $g(W_i){:})F_i/2$, respectively, up to the coefficient *k*, discussed in [5] (see also Eq.(1)): during the early stages of the formation of the universe the symmetry priority shifts to the space - time symmetries. The coupling constants g and gr drop out of the fermion - vector interactions Lagrangian completely, if the *B*: and **W**: fields are defined by Eq.(2) and Eq.(4), respectively. The perturbation series terms should still decrease from the lower to the higher order: the product of probabilities of two (or more) transitions is always less than or equal to the probability of one of the transitions and the vertices in the Feynman diagrams correspond to the transitions between the spinor fields (fermions). This aspect of the theory also supports the idea that fundamentally g and gr are part of the mass generation mechanism only in the shift in the symmetry process bringing quantum field theory one step closer to the theory of gravity.

The structure of the massive Z: field

$$Z{:} \; = \; (gW^3{:} - \; gr B{:}\,)//\{g^2 + gr^2) \qquad (10)$$

somewhat resembles the structure of the covariant derivative, the full differential minus the 'universal influence'2, *B*: related differential: it consists of the difference of the 'creases in space - time' created by the **W**: and *B*: fields. The massless A: field is a different form of manifestation of the fundamental fields, it has a symmetrized or redistributed form of the mass generating factors, g and gr .

$$A{:} \; = \; (grW^3{:} + \; gB{:}\,)//\{g^2 + gr^2) \qquad (11)$$

We can say that the A: field partially regains the pre Big Bang symmetry of the fields. For the gauge transformations of the vector boson W and A field alike we have the coupling constant in the denominator. According to Eq.(1) the bigger the coupling constant the bigger the corresponding particle's mass. Bigger particle mass creates bigger creases in space - time around the particle according to the theory of General Relativity, bigger derivative M:7(x) and the coupling constant in the denominator brings balance to this tendency making the contributions of the 7(x) H**W** and M:7(x)/g terms always comparable to each other. This resonates well with the discussion above of the Z boson and the electromagnetic field A. It is also reasonable to believe that similarity of Eq.(1) to dipole radiation zero condition [9] is not accidental. The tiny deviations of the B: and **W**: fields from their original positions would not lead to some type of radiation at the early stages of formation of space - time. At the Planck distance scale gauge bosons might well form a dipole due to the gravitational attraction. The process which we usually call as Big Bang must be a process of shift in the symmetry and/or symmetry requirements for producing the certain structures which we could call higher instance products. The zigzag picture of nuclear binding energy of chemical elements tells us complex and certainly not unique nature of this process: different universe, different masses of particles and different values for the binding energy of nuclei. The binding energy, nuclei radii and decay time parameters of nuclei from helium up to uranium fit into one quite interesting picture. The experimental data of the radii of atomic nuclei are available only for several chemical elements currently, at least through the internet search. Because the radius of the Helium nucleus has been measured only recently [10], it looks plausible to work with the readily available experimental data. The premodial, more precisely Big Bang times produced elements, Li^7 and Be^7 have visibly small binding energies. Li^7 has a binding energy per nucleon 5.6 MeV.

The available data for its nuclear radius is 4.5 fm [11], which is significantly bigger than the one calculated by the empirical formula

$$r = r_o \; H \; A^{(1/3)} \qquad (12)$$

even when the value r_o = 1.5 *fm* is used for the calculations. The stable isotope of berillium, Be^9 also has a relatively small binding energy per nucleon. The iron Fe^{56} isotope, the isotope with the highest nuclear binding energy per nucleon (together with the Fe^{58} isotope) has a relatively small nuclear radius [12]. The uranium isotopes also reveal these binding energy - nuclear radius - stability tendencies. The nuclear radius of the U^{238} isotope is noticeably larger than that of for the U^{235} isotope, larger than predicted by Eq.(12), has smaller binding energy and substantially larger half - life time. The following table succinctly exhibits these mentioned features of the nuclei.

---

2 Richard Feynman

-

nucleus	binding energy, p.n., MeV	radius, fm	half - life time, 10^9 year
Li^7	5.6	4.5	stable
Be^9	6.30	-	stable
Fe^{56}	8.79	3.74	stable
U^{235}	7.59	7.0	0.704
U^{238}	7.5	7.4	4.5

These features of nuclei fit well into following picture of early stages of the universe's formation. After the first sudden expansion some compression processes also followed for this particular universe. This must be the reason why the binding energies of nuclei have a zigzag form for the primordial nuclei. Different kinds of atoms experienced differently the impact of Big Bang. Li and Be nuclei felt the shift of symmetry at largest scale. They have low binding energy, that means bigger mass per nucleon and bigger nuclear radius (occupying bigger space). The same feature is true for the iron nucleus. Smaller mass per nucleon and smaller nuclear radius. The question here is can the nuclear forces partially squeeze nucleons back into pre Big Bang state here and there? The available data for the uranium isotopes confirm this scenario of the shift in the symmetry with their additional half-life time data. The U^{238} has bigger mass per nucleon, bigger nuclear radius and substantially bigger half-life time. Therefore we can say it had experienced the impact of the Big Bang much more than the U^{235} isotope did so.

We can see the same pattern of the nuclear binding energy - nuclear radius relation among the iron isotopes too. The stable iron isotope Fe^{56}, which is also the most abundant isotope on Earth, has almost the same nuclear radius (3.738 *fm*) as another iron isotope, Fe^{54} (3.735 *fm*) [12], yet it has noticeably higher binding energy per nucleon.

Taking into account the extreme relevance for the daily life, it also looks plausible to discuss the wider range implications of above mentioned features of the nuclear isotopes. Could the life also be another channel of continuation of the Big Bang processes, shift in symmetry processes? The available data on the impact of the lithium and beryllium on human body is consistent with this idea. Lithium, the chemical element with the biggest impact of the shift in the symmetry, is widely used for the healing of the nervous system, the core of the human organism. From the other side the excess of next chemical element with the next biggest impact of the shift in the symmetry processes,

Beryllium often leads to the cancer disease, to the abnormality in DNA, to its hyperactivity. DNA is also the core of the living creatures with a different approach to the matter. So here we see extremely subtle interplay of the nervous system, DNA and after Big Bang, shift in symmetry processes. From what have been said it is tempting to conclude that the nervous system is more fundamental feature of the living creatures than DNA is (lithium vs beryllium), the former revealing itself at the later stages of evolution only.

CONCLUSIONS

The representation of the gauge bosons as the fused states of the fermions allows us to explain a variety of the facts relating to the elementary particles in a natural and simple form. According to this approach to the elementary particles, the triplet of the vector bosons **W**: and the singlet vector boson B: which contributes to the electromagnet interactions only in the capacity of the electroweak interactions intermediaries, originate from the same source. An assumption of the simple relation between the masses of the electroweak vector bosons and coupling constants Eq.(1) leads to the 1) well - known definitions of the Z boson and photons as the mixed states of the **W**: and *B*:, 2) the correct M_Z - M_W relation, which is among the major results of the SM supported by the current experimental data.

The wave functions of the vector bosons built out of the fermion wave functions R(x), the partial derivatives M:, the coupling constants and the generators of the corresponding groups readily reproduce their gauge transformation properties. This successful results somewhat resemble us ancient Greek philosopher Plato s4 endeavors to build the model of the universe out of the regular polyhedra and polygons with the difference being in the usage of the contemporary tools and standards in describing nature.

The self - couplings of the vector bosons belonging to the non - Abelian groups appear to be also the consequence of the shift in the nature of symmetry, the mathematical expression of which is the replacement of the partial derivatives M: by the covariant derivatives *D*:. The u niversality of the gauge couplings occurs because after the shift in the symmetry, certainly the same measure of the 'curvedness' of space - time, gr*B*: (times the hypercharge of the particle) or *g*(W_l):F_l/2, is added to the partial derivatives M:. Besides, different from the *B*:, due to the I_W = 1 value the triplet of the vector bosons **W**: are 'aware' that all the fermions are the members of the electroweak doublets and therefore the fermion - triplet vector boson couplings do not include additional charge factors.

ACKNOWLEDGEMENTS

The author would like to thank Sadiyar Rahimov, director of the Institute for the Physical Problems, Baku State University, for the several helpful +discussions of the phase transitions processes.

---

[1] *S.L. Glashow*. Nuclear Physics 22 (1961), 579.
[2] *S. Weinberg*. Physical Review Letters, 19, 1264.
[3] *A. Salam, N. Svartholm*. Proceedings of the Eighth Nobel Symposium, Almqvist \& Wiksell, Stockholm (1968).
[4] *V. Barger, R. Philips*. Collider Physics, Addison – Wesley Publishing Company, Inc, (1997).
[5] *F. Mamedov*, hep-ph/0606255
[6] *F.Mamedov*. hep-ph/0607010
[7] *S. Eidelman et al., Phys. Lett. B* 592, 1 (2004)
[8] Collaboration, CMS (2019). "Evidence for light-by-light scattering and searches for axion-like particles in ultraperipheral PbPb collisions at /sNN = 5.02 TeV".
[9] Phys. Lett. B. 797: 134826. arXiv:1810.04602. doi:10.1016/j.physletb.2019.134826. S2CID 201698459
[10] *R.W. Brown, K. L. Kowalski, and S.J. Brodsky*. Phys. Rev. D, 28:624, 1983.
[11] https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-82143.html
[12] http://fafnir.phyast.pitt.edu/particles/sizes-3.html
[13] http://nscl.msu.edu/news/news - 25.html