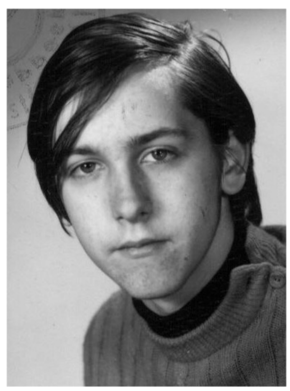
08/2025

The Standard Model Boson Sector and Symmetry Breaking from the Perspective of the Microscopic Theory

Bodo Lampe

II. Institut für theoretische Physik der Universität Hamburg
Luruper Chaussee 149, 22761 Hamburg, Germany



Abstract

In recent years a microscopic model was developed[1, 2, 3] in order to unify the physics of elementary particles and cosmology. The model introduces an underlying microscopic level of invisible 'tetron' matter, the SSB of the SM being interpreted as an alignment of isospin vectors of the tetrons. While earlier work has dealt with the quark lepton spectrum[2, 4] and gravity[3], the present paper concentrates on how the Higgs and the electroweak gauge bosons are to be interpreted as excitations on the underlying structure.

Der Kampf der Vernunft besteht darin,
dasjenige, was der Verstand fixiert hat,
zu überwinden.

G. W. F. Hegel

It is widely believed that the Standard Model of elementary particles is only an effective low energy theory valid below a certain energy scale, which usually is supposed to be of the order of 1-10 TeV, but may in fact be as large as the Planck scale[1]. This view is based on the fact that the SM has many unknown parameters, most notably the quark and lepton masses and mixings, but also the Higgs and gauge boson masses and couplings - the Higgs field being needed for the spontaneous symmetry breaking (SSB) to take place in the model.

A convincing and generally accepted physical understanding of the underlying dynamics responsible for the SM physics is still lacking. For example, in supersymmetric grand unified theories fermion masses essentially remain free parameters. Furthermore, those models usually introduce many more additional degrees of freedom without much ambition to determine them from first principles. The point is that theories of that kind only extrapolate and extend the symmetries observed at low energies to small distances and, as can be concluded from the variety of theories floating around, that there is a strong amount of arbitrariness in this procedure.

In my opinion it is obvious that a determination of the free parameters is only possible in a microscopic theory. Superstring theories and its offsprings seem to offer a solution. However, although 'in principle' able to determine the masses as energies of string excitations, the approach is much to abstract and has not come up with definite and verifiable predictions within almost 50 years.

The present article is devoted to a model which tries to give a microscopic meaning to the Standard Model parameters. According to this model[1] our universe is a 3-dimensional elastic substrate expanding within a 6-dimensional space. The elastic substrate is built from invisible constituents, called tetrons, forming tiny tetrahedrons which extend into the 3 extra dimensions and with bond length about the Planck length and binding energy the Planck energy. Tetrons transform under the fundamental spinor representation of SO(6,1). This representation is 8-dimensional and sometimes called the octonion representation[5].

[1]Indeed, within the present model apart from dark matter effects many BSM effects are suppressed by powers of the Planck length and therefore unobservable. The point is that tetron bonds are extremely short ranged, of the order of the Planck length, c.f. Fig.1, and there is no additional scale in between Fermi and Planck.

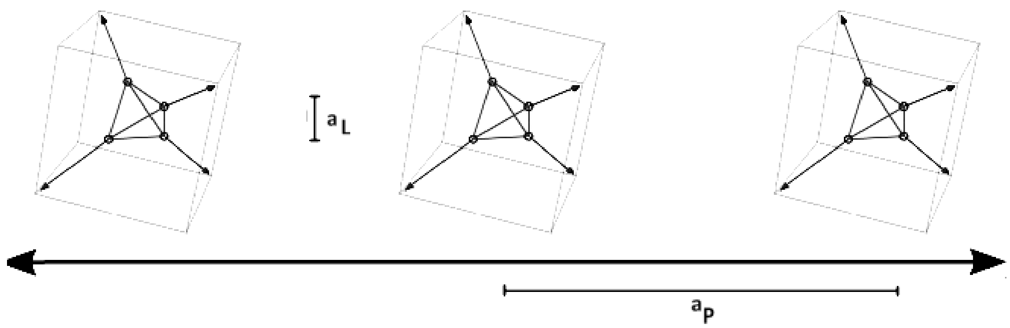


Figure 1: The global ground state of the universe after the electroweak symmetry breaking has occurred, considered at Planck scale distances. The big black double arrow represents 3-dimensional physical space. a_L is the magnitude of one tetrahedron within the 3 extra dimensions and a_P the average distance between two neighboring tetrahedrons. The small arrows are the isospin vectors defined in (4), where actually each arrow stands for 2 vectors $\vec{Q}_L$ and $\vec{Q}_R$ which are aligned in the ground state. Note that the set of arrows on a tetrahedron forms a tetrahedron itself. The figure is a bit misleading, not only because the tetrahedrons do not extend into physical space, but also the relative magnitudes are not correctly drawn. Namely, while a_L and a_P are of the order of the Planck length, the extension of the tetrahedrons formed by the isospin vectors is dictated by the Fermi scale. While gravity can be attributed to the elasticity of the coordinate bonds[3], the phenomena of particle physics arise from the interactions between isospin vectors. The figure shows how our universe looks like in the tetron model. It is part of a 6-dimensional space and is a 3-dimensional 'monolayer' of tetrahedrons each extending into the remaining 3 extra dimensions. The monolayer ground state acts as a background on which quarks and leptons glide as quasiparticle excitations. It has the properties of a Lorentz ether and is thereby not in conflict with Michelson-Morley type of experiments.

More in detail, the global ground state of our universe looks like illustrated in Fig.1, after the electroweak symmetry breaking has occurred, considered at Planck scale distances. It consists of an aligned system of tetrahedrons (the 'fibers') each formed by the isospin vectors of 4 tetrons and extending into the 3 extra dimensions. The picture is a little misleading because in the tetron model the physical space ('base space') and the extra dimensions are assumed to be completely orthogonal.

Before the symmetry breaking the isospin vectors of the tetrons are directed randomly, thus exhibiting a local SU(2) symmetry, but once the temperature drops below the Fermi scale v_F, they become ordered into a repetitive tetrahedral structure, thereby spontaneously breaking the initial SU(2) symmetry. This symmetry actually is a local one, because isospins can be rotated separately over each point of the base space. Note that v_F is the order parameter of the SSB and as such can be related to the length of the aligned isospin vectors.

The tetrons in Fig.1 are depicted as dots. With respect to the decomposition into the (3+1)-dimensional base space and the 3 extra dimensions, a tetron Ψ possesses spin $\frac{1}{2}$ and isospin $\frac{1}{2}$. This means it can rotate independently in physical space and in the extra dimensions, and corresponds to the fact that Ψ decomposes into an isospin doublet

$$\Psi = (D, U) \tag{1}$$

of two ordinary SO(3,1) Dirac fields U and D.

$$\begin{aligned} SO(6,1) &\rightarrow SO(3,1) \times SO(3) \\ 8 &\rightarrow (1,2,2) + (2,1,2) = ((1,2) + (2,1), 2) \end{aligned} \tag{2}$$

where the 'octonion representation' 8 used to describe a tetron comprises particle and antiparticle degrees of freedom within one representation.

The 24 known quarks and leptons arise as eigenmode excitations of the tetrahedral fiber structure. While the laws of gravity are due to the elastic properties of the tetron bonds[3], particle physics interactions take place within the internal fibers, with the characteristic internal energy being the Fermi scale. All ordinary matter thus is constructed as quasiparticle excitations of isospin vectors. Since the quasiparticles fulfill Lorentz covariant wave equations, they perceive the universe as a 3+1 dimensional spacetime continuum.

As set out in earlier publications the tetron model shows the following features:
–The $SU(2)_L \times U(1)$ gauge group of the SM is related to the iso-magnetic Heisenberg $SU(2)$, and the SM SSB can be obtained from a global ordering of internal magnets ('iso-magnets'). The chiral nature of the SM $SU(2)_L$ can be derived from the handedness of the tetrahedrons, the configuration with opposite chirality given by isospin vectors pointing inwards instead of outwards[1]. After the SSB the remaining symmetries are the strong interaction symmetry group, the $U(1)$ of electromagnetism and the discrete tetrahedral symmetry group G_4 of the isospin vectors.
–Due to the pseudovector property of the isospin vectors, G_4 actually is a Shubnikov group[6, 7]. This means, while the coordinate symmetry is S_4, the arrangement of isospin vectors respects

$$G_4 := A_4 + CPT(S_4 - A_4) \tag{3}$$

where $A_4(S_4)$ is the (full) tetrahedral symmetry group. G_4 is unbroken and holds down to the lowest energies. It has only 1- and 3-dimensional representations and describes all 24 SM quarks and leptons after the SSB.
–Quarks and leptons are interpreted as 'iso-magnons' of the discrete 'iso-magnetic' structure and their spectrum can be determined from the dynamical principles of the model, namely from the interaction laws for the isospin vectors. The calculation[2] proves the dominance of the Dzyaloshinskii-Moriya[9] (DM) interactions *within one* tetrahedron, so that actually each internal tetrahedron is a (frustrated) DM isomagnet, cf. the discussion in [2], where also the hierarchy in the masses and the mixing matrices of quarks and leptons has been explained.
–In contrast, DM interactions must not play a role in the 'inter-tetrahedral' interactions of tetrons from two different tetrahedrons, because DMI prefer isospins at 90 degrees while all tetrahedrons are aligned in parallel after the SSB according to Fig.1, and this presupposes dominance of the aligning inter-tetrahedral 'iso-ferromagnetic' Heisenberg interactions. As proven in the present work, this Heisenberg interaction allows to determine the masses of $W^{\pm}$, Z and Higgs in terms of tetron properties, while leaving the photon and the Goldstone modes massless.
–The existence of a fourth family of quarks and leptons. This family, however, is distinct from the other three, not only because it has a very massive neutrino but also because its couplings are much different from the SM. The point is that the

8 Dirac particles of this family do not arise from vibrations of 'iso-magnetizations' $\Psi^\dagger\vec{\tau}\Psi$ in (5) but of 'iso-densities' $\Psi^\dagger\Psi$, and therefore they do not obtain their masses via the Higgs mechanism.
–The tetron interpretation of gravity and dark energy leads to an oscillatory universe (after condensation from a dense tetron gas and subsequent rapid expansion) and a time dependent Newton constant[3]. Measuring the oscillation frequency in future dark energy surveys will allow to determine the full size of the universe (not just its visible part).

In the present paper the analysis is extended to how the Higgs and gauge boson masses and the Weinberg angle can be understood and even determined within the tetron framework. The idea is that excitations of tetrons of 2 neighboring tetrahedrons are responsible for the observed boson sector. Since there are no vibrations in the base physical space one is allowed there to take tensor products of the Dirac fields $(1,2)+(2,1)$ in (2) to arrive at spin-0 and spin-1 objects (in the non-relativistic limit it is simply $2\otimes 2 = 1\otimes 3$). The isospin vibrations then appear, so to speak, on top of the spin-1 and -0 arrangements in the base space.

More in detail the above mentioned isospin vectors are defined as

$$\vec{Q}_L = \frac{1}{4}\Psi^\dagger(1-\gamma_5)\vec{\tau}\Psi \qquad\qquad \vec{Q}_R = \frac{1}{4}\Psi^\dagger(1+\gamma_5)\vec{\tau}\Psi \tag{4}$$

where $\vec{\tau} = (\tau_x, \tau_y, \tau_z)$ are the isospin Pauli matrices, x, y and z being the coordinates of the 3 extra dimensions. Ψ is a tetron field concentrated on one of the corners of a tetrahedron and transforming as the representation 8 introduced in (1) and (2). Each of the arrows in Fig.1 stands for a pair of pseudovectors $\langle\vec{Q}_L\rangle$ and $\langle\vec{Q}_R\rangle$ on each tetrahedral site, where $\langle...\rangle$ denotes the ground state/vacuum expectation values, i.e. after the SSB. $\langle\vec{Q}_L\rangle = \langle\vec{Q}_R\rangle$ pointing outward in the radial direction guarantees for the tetrahedral Shubnikov symmetry[2].

In the present paper I will consider a simplified model where chiral contributions are not included. Instead of (4) I will restrict to one vector only

$$\vec{S} := \vec{Q}_L + \vec{Q}_R = \frac{1}{2}\Psi^\dagger\vec{\tau}\Psi \tag{5}$$

[2]According to (2) the tetron representation 8 contains both particle and antiparticle degrees of freedom. $\vec{Q}_L$ and $\vec{Q}_R$ cover 6 of its 8 dof.The remaining 2 dof correspond to the 'densities' $\Psi^\dagger\Psi$ and $\Psi^\dagger\gamma_5\Psi$ whose fluctuations actually are dark matter candidates[1]. Furthermore, $\vec{Q}_L$ and $\vec{Q}_R$ are particularly useful to handle because quantum mechanically they commute with each other[10].

on each corner of the tetrahedrons and postpone the discussion of chiral effects to later versions of this work. For later use the definition of the tetron density

$$n = \frac{1}{2}\Psi^\dagger\Psi \tag{6}$$

is included. Note that all of these quantities have an energy dimension of 3, which means $\vec{S}$ is not really an angular momentum (which would have dimension 0), but an (angular momentum) density, as are the 'Hamiltonians' discussed below.

The SM Higgs and gauge boson fields are to be considered as excitations of two tetrons Ψ_1 and Ψ_2 belonging to *two neighboring* tetradedrons 1 and 2. So the next step is to consider Heisenberg interactions of 2 vectors $\vec{S}_1$ and $\vec{S}_2$ of type (5) sitting in neighboring tetrahedrons and interacting via an iso-ferromagnetic Hamiltonian. The boson masses will then arise from *inter*-tetrahedral isospin interactions (while quark and lepton masses are due to *inner*-tetrahedral ones). As excitations of single pairs they can be constructed from vibrations δ around the ground states, i.e. one may take the 2 tetrons in the 2 neighboring tetrahedrons to be of the form

$$\Psi_1 = \begin{bmatrix} \delta D_1 \\ \langle U\rangle + \delta U_1 \end{bmatrix} \qquad \Psi_2 = \begin{bmatrix} \delta D_2 \\ \langle U\rangle + \delta U_2 \end{bmatrix} \tag{7}$$

Such an ansatz is always allowed since one is just writing the fields as a vev $\langle\Psi_{1,2}\rangle = (0, \langle U\rangle)$ plus a rest. The vevs corresponds to a state where the isospin vectors $\vec{S}_{1,2}$ are aligned in the ground state and point in the z-direction.

Let me begin with the spin-1 fields. If one considers vibrations of tetrons 1 and 2 in (7), there are altogether 8 vibrational dof. Quite in general 4 of the 8 vibrational eigenstates are given by

$$\delta\,\mathfrak{Re}(D_1 - D_2), \quad \delta\,\mathfrak{Im}(D_1 - D_2), \quad \delta\,\mathfrak{Re}(U_1 - U_2), \quad \delta\,\mathfrak{Im}(U_1 - U_2) \tag{8}$$

whereas the other 4 combinations (with the plus sign) do not play any physical role in an environment of many tetrahedrons.

The expressions (8) are associated to vibrations of $\vec{S}_x$, $\vec{S}_y$, n and $\vec{S}_z$, respectively, to be interpreted as the SM fields W_x, W_y, B and W_z. The physical states $W^\pm$ then correspond to $\delta(D_1 - D_2)$ and $\delta(D_1 - D_2)^\dagger$, and photon and Z-boson to a mixture of the U-vibrations, as explained below after (12).

In contrast to the quark and lepton mass calculation[2] one should start here from the Hamiltonian and not from the eom, because density contributions can then be included more easily. The relevant expression due to isomagnetic exchange is purely of 'ferromagnetic' type, because 2 isospin vectors of neighboring tetrahedrons tend to align, and as discussed before there is no contribution from DM-interactions.

$$H^{(1)}_{inter} = -\frac{1}{\Lambda^2}[g^2\vec{S}_1\vec{S}_2 + g'^2 n_1 n_2] \sim c_W^2\vec{S}_1\vec{S}_2 + s_W^2 n_1 n_2 \tag{9}$$

where *inter* refers to the inter-tetrahedral interactions and the superscript (1) to the spin-1 case, i.e. to the gauge bosons. g and g' are the SM gauge couplings and s_W and c_W sine and cosine of the Weinberg angle.

In order to derive (9) one should remember that the isospin vectors $\vec{S}$ generate the Lie group of isospin rotations which in the SM corresponds to the $SU(2)_L$ gauge symmetry with coupling g while the tetron densities generate the SM U(1) gauge symmetry with coupling g'.

Λ is a new energy scale whose significance will be discussed later after (11). It turns out that as far as the SM is concerned, Λ can be absorbed in a rescaling of the tetron fields. This means that the values of g and g' effectively determine (and are determined by) the strength of the interaction between isospinors in neighboring tetrahedrons.

Note that in the case of iso-ferromagnetic exchange (as contrasted to the iso-anti-ferromagnetic case) the interaction $\sim n_1 n_2$ among the densities is well known to arise[8] inducing density vibrations. This is often ignored in the traditional Heisenberg model (used to describe ferromagnetic magnons) where constant densities are assumed for reasons of simplicity, but will play an important role below in γ-Z mixing and in the determination of the Z and Higgs mass.

$H^{(1)}_{inter}$ is reminiscent of the negative $-D(x_1 - x_2)^2 \equiv -Dx^2$ of the potential of a coupled harmonic oscillator, corresponding to a parabola in the eigencoordinate x. For a SSB to occur, however, an additional positive contribution $\sim x^4$ is needed in the potential

$$V(x) = -Dx^2 + hx^4 \tag{10}$$

to produce a minimum. (This is obviously similar in structure to the form of the SM Higgs potential.)

Note that a quartic term is not included in (9). Its existence has to be assumed, but for determining the masses of the excitations knowledge of its precise form is actually not needed. The point is that the masses can be given in terms of the quadratic coefficients alone, because they are determined by the curvature at the minimum of the potential. This curvature turns out to be $+2D$ in the case of (10) and so does not to depend on h but only on D. The situation is the same in the case of (9) and in fact also in the Higgs potential case where $m_H^2 = 2\mu^2$ does not depend on the Φ^4 coupling value.

One should now work out (9) with the help of (7) and identify the masses from the terms quadratic in δ. More precisely, the coefficient of $\sim [\delta\,\mathfrak{Re}(D_1 - D_2)]^2 + [\delta\,\mathfrak{Im}(D_1 - D_2)]^2$ yield the mass squared of $W^\pm$. One obtains the SM result for the W-mass $m_W^2 = g^2 v_F^2/4$ under the condition that the order parameter, i.e. the Fermi scale v_F is given by

$$\frac{v_F^2}{2} = \frac{|\langle U \rangle|^2}{\Lambda} \tag{11}$$

In principle, the coefficient of $[\delta\,\mathfrak{Im}(U_1 - U_2)]^2$ should yield the mass squared of the W_z and $[\delta\,\mathfrak{Re}(U_1 - U_2)]^2$ of the U(1) field B. As turns out, however, the masses of the neutral gauge bosons cannot be generated this way. To remedy the situation and also obtain the correct mixing of the W_z and B boson field one has to allow for a complex vev

$$\langle U \rangle = |\langle U \rangle| \exp{(i\theta_W)} \tag{12}$$

The phase determines (and is determined) by the Weinberg angle $\theta_W = \arctan(g'/g)$, because evaluation of (9) then leads to one massive combination $Z = W_z c_w - B s_W$ and one massless combination $A = W_z s_w + B c_W$, with the SM result for the Z-mass $m_Z^2 = (g^2 + g'^2) v_F^2/4$ being recovered.

At first sight Λ according to (9) seems to crucially affect the strength of isomagnetic exchange. However, according to (11) the 'strength' of the electroweak SSB is determined by a ratio involving $\langle U \rangle$ and Λ, and one can actually grossly absorb all effects of Λ in a redefinition of the tetron fields $\Psi \to \Psi/\sqrt{\Lambda}$. This rescaling can be interpreted as reducing the 'high' Planck scale values of the tetron fields to the 'low' level of the Fermi scale. Thus, from the very perspective of the SM, the gauge couplings g and g' alone determine (and are determined by) the strength of the isomagnetic exchange.

So, from the viewpoint of the low energy SM, the absolute values of $|\langle U\rangle|^2$ and Λ are not relevant, but only their ratio v_F is. On the other hand, from the viewpoint of the tetron model the values of $|\langle U\rangle|$ and Λ each have a separate physical meaning, and so have the ratios g^2/Λ^2 and g'^2/Λ^2, because these quantites according to (9) correspond to the iso-ferromagnetic couplings of tetron isospins and should be calculable from first principles, i.e. from the form of the fundamental tetron interactions.

If one thinks more closely, only the ratio g/g' (i.e. the Weinberg angle) and the Fermi scale v_F are related to the isomagnetic exchange forces, while the third independent parameter, which is given by the fine structure constant, relates more to the direct (as opposed to exchange) interactions of tetrons, and in fact to gravity[3].

Within the tetron approach it is natural to assume that the measured value of the Weinberg angle of $\theta_W = (28.70 \pm 0.05)^\circ$[11] can be related to the geometry of the tetrahedron - in some way or other. In the following I want to suggest 2 possibilities: (i) 'Hybridization' of isospin-1 vibrations: The 3 orthogonal directions in which $\vec{S}_x$, $\vec{S}_y$ and $\vec{S}_z$ vibrate do not fit well into the tetrahedral structure of 4 tetrons and therefore the states 'hybridize' with the radially symmetric vibration of the density[4]. For the simplified model considered in this work, with $\langle\vec{S}\rangle$ along the z-direction, this

[3]Looking at its definition

$$\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} \tag{13}$$

the fine structure constant is the only dimensionless combination which can be built from the quantities e^2/ϵ_0, h and c. Although α itself is not an energy, it can be written as a ratio of forces or energies. Namely, due to $\hbar c = GM_P^2$ one can rewrite (13) as

$$\alpha = \frac{e^2}{4\pi\epsilon_0 r^{(2)}} / \frac{GM_P^2}{r^{(2)}} \tag{14}$$

i.e. as the ratio of the electrostatic Coulomb (force) energy and the gravitational (force) energy of 2 point particles with elementary charge e and Planck mass M_P at an arbitrary distance r. From this point of view the gravitational force is by no means small as compared to the electric force, but - for such tetron-like test particles - is 137 times stronger!

[4]This is similar to what is called sp3 hybridization in the tetrahedral molecule of methane, where the mixing of one s-orbital and three p-orbitals leads to a wave function of the form $(s+\sqrt{3}p)/2 \approx s_W s + c_W p$.

amounts to a mixture of the n and S_z vibrations with a mixing angle of exactly $\theta_W = 30°$ and a corresponding relative magnitude of $g/g' = \sqrt{3}$.

(ii) Enforcement of the Broglie-Bohr quantization condition: In order that the complete wave function for the ground state corresponds to a standing wave around the 4 corners of a tetrahedron, each tetrahedral corner must contribute a phase of $\theta_T = \arccos(-\frac{1}{3}) \approx 109.5°$ because this is the angle between any 2 isospin vectors in a tetrahedron. On the level of tetrons (which are fermions) this amounts to a phase of $\theta_T/2$, and if without loss of generality one swaps the role of sine and cosine, one ends up with a mixing angle of $\theta_W = \theta_T/4 \approx 27.4°$.

We now turn to the spin-0 states of the SM. They constitute the complex Higgs doublet of the form

$$\Phi = \frac{1}{\sqrt{2}} \exp(\frac{i}{v_F}\vec{\tau}\vec{\xi}) \begin{bmatrix} 0 \\ v_F + H \end{bmatrix} \tag{15}$$

where $\vec{\xi}$ is the triplet of Goldstone bosons and H the physical Higgs field. As explicit from (15), the ξ fields can be gauged to zero by an appropriate SU(2) transformation. This means, although the concept of Goldstone bosons is crucial to understanding symmetry breaking in the Standard Model, there are no physical Goldstone bosons in the observed spectrum.

How does this translate to the microscopic theory? The isospin vibrations (8) can in principle generate fields ξ_x, ξ_y, H andξ_z. Since spin-0 and spin-1 wave functions are different in the base space, ξ_x, ξ_y, H and ξ_z are different from the gauge boson modes, and due to this difference the exhange integrals and accordingly the couplings appearing in the iso-magnetic Hamiltonian will be different as well. Instead of (9) one has

$$H^{(0)}_{inter} = -\frac{\mu^2}{\Lambda^4} n_1 n_2 \tag{16}$$

where Λ is as above and μ^2 the parameter well-known from the Higgs potential leading to a Higgs mass of $m_H^2 = 2\mu^2$. The missing Heisenberg contribution $\sim \vec{S}_1\vec{S}_2$ in (16) makes explicit that there are actually no vibrations which would correspond to particles ξ_x, ξ_y and ξ_z.

The spin-0 case is a rather trivial application of the microscopic model. In essence one is only re-interpreting the quadratic term of the Higgs potential by tetron properties. The hard task is to really calculate the relevant exchange integrals from fundamental tetron interactions.

Let me finish the paper with some personal remarks about the history of the microscopic model. The ground laying idea actually started as early as 1987. When I visited Fermilab that summer, I was accompanied by my wife and our son half a year old. We stayed for a month and were given the opportunity to live in one of the traditional houses on the Fermilab property. We did it with ease to bring the fire brigade to the scene on one of the first days.

At that time there were the 'preon models' - assuming quarks and leptons to be composed of smaller constituents - and the community had just agreed that such models cannot be built in a natural and consistent manner, most of all because of the extreme difference between the pointlikeness and necessarily high masses of the constituents and the relatively small masses of most quarks and leptons. I had followed the ansatz with curious interest, but not written any paper on the subject, feeling that this kind of approach was missing some essential ingredient.

Anyhow my main work was on QCD and my task at Fermilab was to discuss properties of hadron jets with someone from the lab staff. We had some interesting conversations, but when it came to filling a permanent scientific position the other year, I got away empty handed, as in all other institutions where I ever introduced myself.

The colleague had time only in the afternoons, so in the mornings I felt free to try to invent some ideas about the underlying nature of the quark lepton multiplet structure. There are so many reliable experimental results in that area that I thought quark and lepton properties to be a good starting point in order to develop a really fundamental theory. I further thought that if anything is of importance at all in this world of shadows, it is not biology or logic, not money or the rules of societies, but the deep structure of the physical universe.

I did not want to follow the mainstream SUSY, GUTs, Strings etc. These models emphasize symmetry (which is important, no question) but do not place enough value on a possible real material background, on which in my opinion any symmetry structure having to do with matter has to rely. I wanted to take this into account, when starting to develop a unified theory of my own. Since I had made elaborate studies in natural philosophy, I thought that I could do better.

In reality, my considerations did not start with such high demands. I set my sights lower and tried to get forward step by step. So actually, during my Fermilab stay I did not come up with final answers. I just made some observations which were to become important in later years. Namely, I noticed that the total of 24 quarks and leptons had some structural similarity to the ordering of the 24 group elements of the tetrahedral point group. Could be an accident, but I scanned many possibilities and did not find better answers.

Since as a young student I had some interest in theoretical chemistry, I began to restudy some textbooks on the tetrahedral point group with the idea in mind that tetrahedrons could supply a quark lepton substructure in a somehow more consistent manner than preon models do. It was only much later, in the new millenium, that I began to consider physical space to be made up of a discrete tetrahedral isospin arrangement and the observed 'elementary particles' as excitations thereon.

The tetrahedral point group stayed in my head for a while, before I decided to publish[12], at least as a preprint, in 1998. Shortly afterwards I left scientific research because I did not find a permanent position. For a while I was frustrated and avoided all physics topics. It was only another 10 years later and after writing a novel of about 1000 pages, dealing with the side issues of life, that I returned to the problem, now as a private scholar and at first in a rather playful manner.

The first main problem I encountered was that the representation spaces of the tetrahedral group do not match the quark lepton multiplet structure exactly. In 2012 I realized that one of the tetrahedral black-and-white point groups when taken over from spin to isospin space does a better job. Accordingly, I introduced a tetrahedron of isospin vectors, and considered their interaction as a sort of 'iso-magnetism'. Quarks and leptons were then interpreted as vibrations of the isospin vectors. I noticed quite soon that there naturally arise 3 massless modes (interpreted as neutrinos) whose masselessness can be attributed to the conservation of isospin. I furthermore realized that (in contrast to an ordinary tetrahedron) a tetrahedron of pseudovectors is chiral, and that this can be used to explain the parity violation of the weak interacation.

In 2013 I united physical and isospin space to a larger 6-dimensional space, with a corresponding 6+1 dimensional spacetime continuum and began to understand the SM Higgs mechanism as an alignment of isospin vectors in that space[1]. This requires that each point of 3-dimensional physical space actually is a tetrahedron, not extending into physical space but into the 3 extra dimensions. In other words, our universe is nowhere empty but an elastic substrate, microscopically formed by discrete tetrahedrons. The tetrahedrons consists of tetrons transforming according to (2) and making up the backbone of our universe. Furthermore, the transformations in isospin space are not just abstract symmetry operations but corresonds to real rotations in 3 extra dimensions.

At the end of the 2010s, I dealt with cosmological implications of the model[3]. Afterwards I turned to quark and lepton mixing matrices and found a way to determine them within the tetron theory[2].

References

[1] B. Lampe, arXiv:1505.03477 [hep-ph] (2015).

[2] B. Lampe, Fortsch. Phys. 72 (2024) 5, 2300258.

[3] B. Lampe, Progr. of Phys. 69 (2021) 2000072.

[4] B. Lampe, Int. J. Mod. Phys. A30 (2015) 1550025.

[5] R. Slansky, Phys. Rept. 79 (1981) 1.

[6] A.P. Cracknell, Progr. Theor. Phys. 35 (1966) 196.

[7] A.P. Cracknell, Progr. Theor. Phys. 33 (1965) 812.

[8] A. Auerbach, Interacting Electrons and Quantum Magnetism, Springer, 1994.

[9] I. Dzyaloshinskii, J. Phys. Chem. Sol. 4 (1958) 241.

[10] S. 0neda and K. Terasaki, Prog. Theor. Phys. Suppl. 82 (1985) 1.

[11] Particle Data Group, Prog. Theor. Exp. Phys. (2024) 083C01.

[12] B. lampe, arXiv:hep-ph/9810417.