Hypersphere space-time model

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Abstract

The origin of the three spatial dimensions as well as the one of time can be deduced from fundamental principles (symmetry). The structure resulting from this construction looks like an hypersphere in which each energy particle constitutes a dimension, forming a loop or a string covering the whole universe. This model shall be linked to the existing theories that are consistent with the reality as measured by experiments.

Article

Space

Quantum wave

Nothing (symmetry) generating something (energy) can be expressed by the addition and the multiplication of an energy quantum (a) and its opposite ($\bar{a}$) :

$a + \bar{a} = 0$ (symmetry) $a\bar{a} = 1$ (energy)

The solution is

$a = i$ $\bar{a} = -i$

where $i^2 = -1$. The quantum (a) is a complex number that could be considered as the π/2 phase of a virtual (potential) standing wave whose wavelength covers the whole universe. It’s the same for the opposite ($\bar{a}$).

Quaternion

The quantum (a) and its opposite ($\bar{a}$) form a pair of complex numbers ($a,\bar{a}$). These two elements on their own dimension are linked together thanks to a new dimension with the external or vectorial product ∧ : $a \wedge \bar{a} = v$. The vector (v) exists in a three dimensional space ($a,\bar{a},a\wedge\bar{a}$) that can be represented by a quaternion $q \in \mathbb{H}$

$q = s + i\,(v) = x_0 + x_1 i_1 + x_2 i_2 + x_3 i_3$

where $x_0, x_1, x_2, x_3 \in \mathbb{R}$, $i^2 = i_1^2 = i_2^2 = i_3^2 = i_1 i_2 i_3 = -1$, $s = x_0 = 0$ is the scalar part, $(v) = (x_1,x_2,x_3)$ is the vectorial part.

Some mathematical operations can be applied to a quaternion (q) or (q') :

closed product: **qq'** $= ss'-v.v' + i\,(sv'+s'v+v\wedge v') \in \mathbb{H}$

conjugate: $\bar{\mathbf{q}} = s - i\,(v) = x_0 - x_1 i_1 - x_2 i_2 - x_3 i_3$

braket product: $\mathbf{<q|q'>} = q\bar{q}'$

euclidian norm: $\mathbf{||q||} = \sqrt{<q|q>} = \sqrt{x_0^2 + x_1^2 + x_2^2 + x_3^2}$

inverse: $\mathbf{q^{-1}} = \bar{q}/||q||^2 \Rightarrow qq^{-1} = 1$

right division: $\mathbf{q/q'} = qq'^{-1} = q\bar{q}'/||q'||^2 = <q|q'> / <q'|q'>$

commutator: $\mathbf{[q,q']} = qq' - q'q$

anticommutator: $\mathbf{\{q,q'\}} = qq' + q'q$

scalar product: $\mathbf{<q,q'>} = (<q|q'> + <q'|q>)/2 = ss'+v.v' = x_0x'_0 + x_1x'_1 + x_2x'_2 + x_3x'_3$

unitary quaternion: $\mathbf{u} = q/||q|| \Rightarrow ||u|| = 1$

where $v.v' = v'.v = x_1x'_1 + x_2x'_2 + x_3x'_3$ is the internal or scalar product of vectors, $v\wedge v' = -v'\wedge v = (x_2x'_3-x_3x'_2, x_3x'_1-x_1x'_2, x_1x'_2-x_2x'_1)$ is the external or vectorial product of vectors.

By definition, the product is half of the addition of the commutator and the anticommutator :
$qq' = (\{q,q'\} + [q,q'])/2$. The product is not commutative in general ($qq' \neq q'q$ if $v\wedge v' \neq 0$). That's why the commutator could be non-null and the anticommutator could be null. The conjugate of a product is the commutated product of its conjugate elements ($q = q_1q_2 \Rightarrow \overline{q} = \overline{q}_2\overline{q}_1$). There is always an inverse for a non-null quaternion because the norm is not null in this case. The braket product acts like a (right) division up to a positive real number, the squared norm $||q||^2$, it is not commutative and even not associative in general.

A quaternion can be expressed by a linear combination of 2×2 complex matrices σ_k

$$q = x_0\, \sigma_0 + x_1\, i\, \sigma_1 + x_2\, i\, \sigma_2 + x_3\, i\, \sigma_3$$

where i is the imaginary number ($i^2 = -1$), σ_0 is the unit matrix and σ_k (k = 1,2,3) are the Pauli matrices

$$\sigma_0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \equiv \mathbb{1} \qquad \sigma_1 = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} \equiv -i\, i_1 \qquad \sigma_2 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \equiv -i\, i_2 \qquad \sigma_3 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \equiv -i\, i_3$$

The quaternion is a piece of momentum, a piece of energy. Energy conservation implies that the result of the operation on two pairs of quanta shall not be null and can be reversed, which is in adequation with the quaternionic multiplication and division. So each fundamental element covering the whole universe can be represented by a quaternion. It's the Hamilton's dream.

Homogeneity

Considering that the universe is made of such fundamental energy elements, energy conservation implies a constant (finite) number of such elements or else an homogeneity that means that all elements are identical or even both, constant number of elements and homogeneity. Homogeneity seems to be a principle and it will be supposed.

According to the homogeneity principle, all quaternions can be considered as unitary quaternion ($u \in \mathbb{H}$, $||u|| = 1$). The easiest way to explain homogeneity is to have only one element that interacts with itself in several ways but this extreme hypothesis will require further study.

Orthogonality

Each fundamental energy element has - or "is" because there is no other characteristic - its own three dimensional (3D) space, perfectly in accordance with the special relativity. Assuming that all the elements are indistinguishable implies that they are identical. But assuming that each element has its own existence implies that the elements are independant to each others and that there is an orthogonal representation of them. Each element is on its own dimension, forming an hypersphere of 3D spaces, an hypersphere of quaternions.

For pure vectorial quaternions ($q = i\, v$), the anticommutator is equivalent to the scalar product of vectors and the commutator is equivalent to the vectorial product of vectors.

$$\{q,q'\} = \{i\, v, i\, v'\} = -2\, v.v'$$

$$[q,q'] = [i\, v, i\, v'] = 2i\, v\wedge v'$$

The orthogonality between quaternions is defined by a null scalar product ($\langle q,q'\rangle = 0$) and for pure vectorial quaternions ($q = i\, v$), by a null scalar product of vectors ($v.v' = 0$) which is equivalent to a null anticommutator ($\{v,v'\} = 0$).

Mass

In a first approach, mass existence could be linked to a non negative value of the scalar part ($s = x_0 \neq 0$) of the quaternion, the norm forming the Minkowski space $t^2 = s^2 + x_1^2 + x_2^2 + x_3^2$. But the quaternion is here unitary and purely vectorial ($s = 0$). Furthermore, this approach doesn't answer to a lot of questions.

Mass is specific to some particles, to some set of energy, not to all kind of energy. Mass is expressed inside the Dirac equation. Mass comes from external interaction with the BEH (Higgs) boson, this interaction changes the chirality of the particle. Mass is constant at rest and is spread in 3 generations, according to some relations (e.g. CKM and PMNS matrices). Mass is annihilated by the antiparticle. All these different things shall match. The following explores some research areas but it needs to be developed deeper and more rigorously.

Dirac equation

The Dirac equation for a free particle is, adding to k = 1,2,3,

$$\left[i\hbar \frac{\partial}{\partial t} \right] \psi(\mathbf{x},t) = \left[mc^2 \alpha_0 - i\hbar c\, \alpha_k \frac{\partial}{\partial x_k} \right] \psi(\mathbf{x},t)$$

where c is the constant speed of light, ħ = h/π is the reduced Planck constant, *i* is the imaginary number ($i^2 = -1$), $\psi(\mathbf{x},t) = \psi(x_1,x_2,x_3,t)$ is a four dimensional complex vector as solution, called a Dirac spinor.

The goal of the Dirac equation is to obtain the Klein-Gordon equation when its terms are squared. To do this, the α_k (k = 0,1,2,3) terms must obey the following rules :

$$\alpha_k^2 = 1 \qquad \{\alpha_k,\alpha_{k'}\} = \alpha_k\alpha_{k'} + \alpha_{k'}\alpha_k = 0 \quad (k \neq k')$$

One common representation of α_0 and α_k (k = 1,2,3) amoung many others is the following 4×4 complex matrices where σ_k are the Pauli matrices.

$$\alpha_0 = \begin{bmatrix} \sigma_0 & 0 \\ 0 & -\sigma_0 \end{bmatrix} = \begin{bmatrix} \mathbb{1} & 0 \\ 0 & -\mathbb{1} \end{bmatrix} \qquad \alpha_k = \begin{bmatrix} 0 & \sigma_k \\ \sigma_k & 0 \end{bmatrix}$$

Mass dimension

By setting $\varphi = \psi\, e^{ix_0 mc/\hbar}$, $\partial_t = \partial/\partial t$, $\partial_k = \partial/\partial x_k$, the Dirac equation can be rewritten in a simpler and more homogeneous form, adding to k = 0,1,2,3

$$\partial_t \varphi + c\, \alpha_k\, \partial_k\, \varphi = 0 \qquad (1)$$

because

$$\partial_0\, \varphi = \psi\, \partial_0\, e^{ix_0 mc/\hbar} = (imc/\hbar)\, \psi\, e^{ix_0 mc/\hbar} = (imc/\hbar)\, \varphi$$

The x_0 parameter acts like a specific dimension for mass, in the same way as the 3 spatial dimensions x_1, x_2, x_3.

Mass generations

Representing 3 generations of mass instead of one generates 3 coordinates (y_1,y_2,y_3) instead of one (x_0). The φ function is adapted, with $m_1^2 + m_2^2 + m_3^2 = m^2$

$$\varphi = \psi\, e^{ix_0 mc/\hbar} = \psi\, e^{i(y_1 m_1 + y_2 m_2 + y_3 m_3)c/\hbar}$$

The α_0 matrix shall be replaced by a linear combination of β_k matrices

$$m\, \alpha_0 = m_1\, \beta_1 + m_2\, \beta_2 + m_3\, \beta_3$$

that follow the rules of the Dirac equation

(1) $\beta_k^2 = 1$

(2) $\{\beta_k,\beta_{k'}\} = 0 \quad (k \neq k')$

(3) $\{\alpha_k,\beta_{k'}\} = 0$ $(k,k' = 1,2,3)$

Using the Pauli matrices σ_k for β_k, as for α_k, seems to be a natural choice.

$$\beta_k = \begin{bmatrix} \sigma_k & 0 \\ 0 & -\sigma_k \end{bmatrix}$$

Unfortunately, the two first rules are respected but not the third one for $k \neq k'$, because the commutativity between σ_k and $\sigma_{k'}$ is required ($\sigma_k\sigma_{k'} = \sigma_{k'}\sigma_k$) while $\sigma_k\sigma_{k'} = -\sigma_{k'}\sigma_k$

$$\{\alpha_k,\beta_{k'}\} = \alpha_k\beta_{k'} + \beta_{k'}\alpha_k = \begin{bmatrix} 0 & -\sigma_k\sigma_{k'} \\ \sigma_k\sigma_{k'} & 0 \end{bmatrix} + \begin{bmatrix} 0 & \sigma_{k'}\sigma_k \\ -\sigma_{k'}\sigma_k & 0 \end{bmatrix} \neq 0$$

In fact, the rule (3) as the anticommutativity between any α_k and any $\beta_{k'}$ is too demanding to obtain the Klein-Gordon equation. We can only consider anticommutativity of two elements α and β ($\{\alpha,\beta\} = 0$) where α is a linear combination of α_k and β is a linear combination of β_k.

$$(\alpha + \beta)^2 = \alpha^2 + \{\alpha,\beta\} + \beta^2 = \alpha^2 + \beta^2 = (\Sigma\ \alpha_k)^2 + (\Sigma\ \beta_k)^2 = \Sigma\ \alpha_k^2 + \Sigma\ \beta_k^2$$

Let's create α and β.

$$\sigma = \lambda_1\ \sigma_1 + \lambda_2\ \sigma_2 + \lambda_3\ \sigma_3 \qquad \text{where } \lambda_1^2 + \lambda_2^2 + \lambda_3^2 = 1$$

$$\sigma' = \mu_1\ \sigma_1 + \mu_2\ \sigma_2 + \mu_3\ \sigma_3 \qquad \text{where } \mu_1^2 + \mu_2^2 + \mu_3^2 = 1$$

$$\alpha = \begin{bmatrix} 0 & \sigma \\ \sigma & 0 \end{bmatrix} \qquad \beta = \begin{bmatrix} \sigma' & 0 \\ 0 & -\sigma' \end{bmatrix}$$

$$\{\alpha,\beta\} = \alpha\beta + \beta\alpha = \begin{bmatrix} 0 & -\sigma\sigma' \\ \sigma\sigma' & 0 \end{bmatrix} + \begin{bmatrix} 0 & \sigma'\sigma \\ -\sigma'\sigma & 0 \end{bmatrix}$$

The anticommutator is null ($\{\alpha,\beta\} = 0$) only if σ and σ' commute ($\sigma\sigma' = \sigma'\sigma$). So σ and σ' shall be linearly dependant ($\sigma' = \lambda\sigma$, $\lambda \in \mathbb{R}$). Because $\sigma'^2 = \lambda^2\sigma^2 = 1$ and $\sigma^2 = 1$, then $\lambda = \pm 1$ and $\sigma' = \pm\ \sigma$. By defining the 4×4 complex matrix $\mathbb{i}$

$$\mathbb{i} = \begin{bmatrix} 0 & \mathbb{1} \\ -\mathbb{1} & 0 \end{bmatrix}$$

the α and β are related by

$$\beta = \pm\ \mathbb{i}\ \alpha \ \Rightarrow\ \begin{matrix} \beta = \mathbb{i}\ \alpha \\ \beta = -\mathbb{i}\ \alpha = \alpha\ \mathbb{i} \end{matrix} \ \Rightarrow\ \begin{matrix} \beta_k = \mathbb{i}\ \alpha_k \\ \beta_k = \alpha_k\ \mathbb{i} \end{matrix} \qquad (2)$$

From (1), the Dirac equation for 3 generations of mass becomes, with $\partial^x{}_k = \partial/\partial x_k$, $\partial^y{}_k = \partial/\partial y_k$ and adding to $k = 1,2,3$

$$\partial_t\ \varphi = -c\ \left[\alpha_k\ \partial^x{}_k + \beta_k\ \partial^y{}_k\right]\ \varphi$$

and from (2), the above equation becomes

$$\partial_t \varphi = -c\, \alpha_k \left[\partial^x{}_k \pm \mathbb{i}\, \partial^y{}_k \right] \varphi$$

Biquaternion

Splitting the 4-dimensional vector $\varphi = (\varphi_1,\varphi_2,\varphi_3,\varphi_4)$ into two 2-dimensional vectors $\varphi_L = (\varphi_1,\varphi_2)$, $\varphi_R = (\varphi_3,\varphi_4)$ and expressing the α_k and β_k matrices give,

$$\partial_t \begin{bmatrix} \varphi_L \\ \varphi_R \end{bmatrix} = -c \left[\begin{bmatrix} 0 & \sigma_k \\ \sigma_k & 0 \end{bmatrix} \partial^x{}_k + \begin{bmatrix} \sigma_k & 0 \\ 0 & -\sigma_k \end{bmatrix} \partial^y{}_k \right] \begin{bmatrix} \varphi_L \\ \varphi_R \end{bmatrix}$$

which can transform the Dirac equation in two equations

$$\partial_t \varphi_L = -c\, \sigma_k \left[\partial^x{}_k \varphi_R + \partial^y{}_k \varphi_L \right] = i\, c\, i_k \left[\partial^x{}_k \varphi_R + \partial^y{}_k \varphi_L \right]$$

$$\partial_t \varphi_R = -c\, \sigma_k \left[\partial^x{}_k \varphi_L - \partial^y{}_k \varphi_R \right] = i\, c\, i_k \left[\partial^x{}_k \varphi_L - \partial^y{}_k \varphi_R \right]$$

The φ_L and φ_R complex vector can be replaced by two 2×2 complex matrices

$$\Phi_L = \begin{bmatrix} \varphi_1 & 0 \\ \varphi_2 & 0 \end{bmatrix} \qquad \Phi_R = \begin{bmatrix} 0 & \varphi_3 \\ 0 & \varphi_4 \end{bmatrix}$$

Adding first equation to the second one, multiplied by *i*, and setting c = 1, $\Phi = \Phi_L + i\,\Phi_R$, $\Phi^* = \Phi_L - i\,\Phi_R$

$$\partial_t \Phi = i\, i_k\, \partial^x{}_k \Phi_R + i\, i_k\, \partial^y{}_k \Phi_L - i_k\, \partial^x{}_k \Phi_L + i_k\, \partial^y{}_k \Phi_R = -i_k\, \partial^x{}_k \Phi^* + i\, i_k\, \partial^y{}_k \Phi^*$$

or, by defining

$$\nabla_t = \partial_t \qquad \nabla^* = i_k\, \partial^x{}_k - i\, i_k\, \partial^y{}_k$$

finally giving

$$\nabla_t \Phi = -\nabla^* \Phi^*$$

The Φ matrix as any 2×2 complex matrix is a biquaternion : a sum of a normal quaternion and another quaternion multiplied by the imaginary number *i* or, equivalently, a quaternion with complex coefficients instead of real ones.

$$b = z_0 + z_1 i_1 + z_2 i_2 + z_3 i_3 = (x_0+iy_0) + (x_1+iy_1)i_1 + (x_2+iy_2)i_2 + (x_3+iy_3)i_3 = q_x + i\, q_y$$

where $z_k \in \mathbb{C}$, x_k and $y_k \in \mathbb{R}$, q_x and $q_y \in \mathbb{H}$, $b \in \mathbb{H}_\mathbb{C}$. The isomorphism between biquaternion and 2×2 complex matrix ($\mathbb{H}_\mathbb{C}$ ≅ M_2(ℂ)) can easily be shown

$$b = z_0\, \sigma_0 + z_1\, \sigma_1 + z_2\, \sigma_2 + z_3\, \sigma_3 = \begin{bmatrix} z_0 & 0 \\ 0 & z_0 \end{bmatrix} + \begin{bmatrix} 0 & -z_1 \\ z_1 & 0 \end{bmatrix} + \begin{bmatrix} 0 & iz_2 \\ iz_2 & 0 \end{bmatrix} + \begin{bmatrix} iz_3 & 0 \\ 0 & -iz_3 \end{bmatrix} = \begin{bmatrix} z_0+iz_3 & iz_2+z_1 \\ iz_2-z_1 & z_0-iz_3 \end{bmatrix}$$

The Φ_L and Φ_R 2×2 complex matrices, also called Weyl spinors, are also biquaternions but without inverse because the matrix representation has no inverse, the determinant is null. Unlike the quaternion, the biquaternion does not always have an inverse.

Like the normal Dirac equation, the extended to 3 generations of mass Dirac equation can be expressed by biquaternions instead of α_k matrices and φ spinor.

Lie group

The set of unitary quaternions (u) is isomorphic to the SU(2) Lie group, the $i\sigma_k$ are the generators. It means that the exponential of a linear combination of the Pauli matrices ($\sigma = x_1\sigma_1 + x_2\sigma_2 + x_3\sigma_3$) is a unitary quaternion. Indeed, the series expansion of the exponential function applied to matrices allows to write

$$u = e^{i\sigma} = e^{i\theta\upsilon} = \cos(\theta) + i \sin(\theta)\ \upsilon$$

where $\theta^2 = ||\sigma||^2 = x_1^2 + x_2^2 + x_3^2$, $\upsilon = \sigma/\theta$ is the unitary vector $\upsilon^2 = 1$.

The SU(2) Lie group is homomorphic to the SO(3) Lie group. An uncommon representation of the SO(3) generators is

$$J_1 = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad J_2 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix} \qquad J_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

and SO(3) generators with imaginary number *i*, keeping determinant value as 1, can be represented by

$$I_1 = \begin{bmatrix} 0 & i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad I_2 = \begin{bmatrix} 0 & 0 & i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{bmatrix} \qquad I_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & i \\ 0 & i & 0 \end{bmatrix}$$

The I_k and J_k matrices, in addition to the two following independant vectorial matrices

$$I_0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad J_0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{bmatrix}$$

is similar to the Dirac equations and to a biquaternion (8 dimensions). The two above matrices with the I_k and J_k ones, multiplied by *i*, also represent the Gell-Mann matrices, the generators of the SU(3) Lie group. So there is a link between a biquaternion and the SU(3) Lie group, used to represent the strong interaction and the CKM/PMNS matrices.

Mass is space

In an highly speculative manner and with a lot of shortcuts, some conclusions can be assumed.

- The basis is a biquaternion instead of a quaterion, which is the vector of the quantum wave.
- A particle is a spinor which is a biquaternion without inverse, that can explain why a particle exists and cannot be divided.
- The mass of the particle is the mirror of the momentum on its three dimensions, that's why mass has three generations.
- The mass and the momentum are undistinguishable and can be exchanged, changing chirality.
- Energy as mass are both space.

Interaction

An interaction can be summerized by a merge or break in the biquaternion hypersphere structure.

A particle is a discrete volume of 3D spaces or momentum in the hypersphere. The number of 3D spaces is the number of dimensions and it could be odd or even, which could correspond to fermion or boson.

An interaction is a division of a particle (p_1) by another particle (p_2) thanks to a bra-ket product $\langle p_1|p_2\rangle = p_1\overline{p}_2$; But the operation is an equality that can arise in both directions : p_1 and p_2 generate $p_1\overline{p}_2$ or $p_1\overline{p}_2$ generates p_1 and p_2.

The 3D space of $p_1\overline{p}_2$ is a combination of the 3D spaces of p_1 and p_2, which can be done in two ways (chirality). The 3D space combination is the result of the closed product of biquaternion. The two possible combinations is the result of the non-commutativity of the multiplication of biquaternions. Because of orthogonality of particles p_1 and p_2, the result $p_1\overline{p}_2$ of the division is perpendicular to the original particles, with two possible directions. That explains why an interaction is punctual and has several possibilities. The result of the interaction generates always one or two particles that share the same 3D space until the next interaction.

An interaction is a break or a merge of 3D spaces. It can also be seen as a rotation in the hypersphere of biquaternions. As seen at the beginning of the article, a quantum of space is like a biquaternionic potential wave and the interaction has effect on the wave. A merge of 3D spaces is a merge or multiplication of the corresponding waves which implies addition of the frequencies. The rotation in the hypersphere acts like a phase change of the wave but the interaction change the reference of the phase, not the phase itself. The interaction is also called collapse of the wave function. The probability of interaction is relative to the sum of the wave functions in the corresponding 3D space reference but the cause of the interaction remains unknown.

Propagation of the particle (p) is the interaction of the particle by itself $\langle p|p\rangle$ that is expresses by the norm or the Minkowski space $\langle p|p\rangle = s^2+x_1^2+x_2^2+x_3^2 = c^2t^2$.

The standard model U1×SU2×SU3 can be generated by biquaternions because $\mathbb{B} \equiv SU3 \supset SU2 \supset U1$. All the interaction forces are in the mass (potential) dimension. They influence the probability of interaction but not the interaction itself, which remains orthogonal and euclidian. That's why our 3D space is flat.

Entanglement has an obvious solution here. The entangled particles share the same 3D space during and after the interaction. They propagate in their common 3D space. During the interaction of one of the two particles with a third one, the 3D space of the two particles combines randomly with the 3D space of the third one. The set of these interaction points forms our common interaction 3D space.

We can imagine different common interaction spaces, a bit like multiple universes. But only the common interaction spaces with a physical significance has a meaning, that's why there is perhaps only one common interaction space.

Time

Time is not fundamental. The additional dimension to space is the mass, not the time. The hypersphere structure is static, stationary, without time.

Changes occur in the common interaction space thanks to the interactions. Time is the wave propagation or the result of the self-interaction of a particle, relative to the last interaction point.

The principle of causality, which is commonly related to time, can be explained by the non-associativity of the biquaternionic division or bra-ket product. The order of divisions, which means the order of interactions, must generally be taken into account.

Conclusion

Based on the hope that Nature is simple, this article introduces a new representation of space-time structure of the universe : an hypersphere structure on a multi-dimensional space. Each dimension is an energy quantum with its opposite forming a three dimensional space, as biquaternion, covering the whole universe. The structure generates the space and the mass, which are equivalent. Time is the result of interactions which take place in a three dimensional reference space. The implications of this hypothesis are vast and go far beyond this short article. This article focuses on build blocks of the structure but does not explore the rules of interactions, which is perhaps a big work.

Whether the theory is correct or not, it seems increasingly clear that the visible common space-time is not a fundamental structure. Elementary particles are supposed to be punctual but have information (charge, mass), so it's an evidence that there is more dimensions to contain this information, not only in an absctract mathematical space but in reality. Elementary particles are also fields that spread to the whole universe and the fields are also a reality. Our space-time is only the visible consequence of the interaction between particles. That’s why calculations based only on our visible space-time can become unstable. To explain the universe, the ether is not necessary and perhaps not space-time either.