Structure of physical reality

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Abstract

Obviously, physical reality possesses structure, and this structure founds on one or more foundations. These foundations are rather simple and easily comprehensible. The major foundation evolves like a seed into more complicated levels of the structure, such that after a series of steps a structure results that appears like the structure of the physical reality that humans can partly observe. To show the power of this approach the paper explains the origin of gravity and the fine structure of photons and elementary particles.

1 Introduction

The document applies the name physical reality to comprise the universe with everything that exists and moves therein. It does not matter whether the aspects of this reality are observable. It is even plausible that a large part of this reality is not in any way perceptible. The part that is observable shows at the same time an enormous complexity, and yet it demonstrates a peculiarly large coherence. The conclusion is that physical reality clearly has a structure. Moreover, this structure has a hierarchy. Higher layers are becoming more complicated. That means immediately that a dive into the deeper layers reveals an increasingly simpler structure.

Eventually, we come to the foundation, and that structure must be easily understandable. The way back to higher structure layers delivers an interesting prospect. The foundation must force the development of reality in a predetermined direction. The document postulates that the evolution of reality resembles the evolution of a seed from which only a specific type of plant can grow. The growth process provides stringent restrictions so that only this type of plant can develop. This similarity, therefore, means that the fundamentals of physical reality can only develop the reality that we know.

This philosophy means that the development of physics can occur in two different ways that meet each other at a certain point and then complement and correct each other.

1.1 Conventional physics

The first, already long in use mode uses the interpretation of perceptions of the behavior and the structure of the reality. This method provides descriptions that in practice are very useful. This fact is especially true if mathematical structures and formulas can capture the structure and the behavior. In that case, the result fits the description to not yet encountered situations. This effect has made the field of applied physics very successful. However, the method does not provide reliable explanations for the origins of the discovered structure and the discovered behavior. This situation gives rise to guesswork, that gambles for the discovery of a usable origin. So far, these efforts have not proved very fruitful.

1.2 From the ground up

The other way suggests the existence of a potential candidate for the foundation of physical reality. The method supposes that this foundation has such a simple structure that intelligent people have already added this structure as an interesting structure to the list of discovered structures. For them, there existed no need to seek the foundation of reality. We can assume that mathematics already includes the foundation of the structure of reality without this structure bearing the hallmark "Foundation of Reality." However, this structure will carry the property, which says that this simple structure automatically passes into a more complicated structure, which in turn also emerges into a more complicated structure. After some evolutionary steps, it should become apparent that the successors of the initial structure increasingly contain the properties and support the behavior of the observed reality. In other words, the two approaches will move towards each other.

2 Framework

The quest for a suitable candidate for the major foundation seems almost impossible, but we are lucky. About eighty years ago, two scholars discovered a mathematical structure that seems to meet the conditions. It happened in a turbulent time when everyone was still looking for an explanation for the behavior of tiny objects. One of the two scholars, John Von Neumann, searched for a framework in which scientists can model quantum mechanics. The other scholar, Garrett Birkhoff, was a specialist in relational structures, which the mathematicians call lattices. Together they introduced the orthomodular lattice, and they decided to name this structure quantum logic. They chose this name because the lattice structure of the already known classical logic closely resembles the newly discovered quantum logic. This choice was an unfortunate naming because the discovered structure proves to be no logical system at all. Its elements are not logical propositions. In the document, in which the duo introduced their discovery, they proved that a recently by David Hilbert discovered structure contains an orthomodular lattice as part of its structure. The discovery of David Hilbert is a vector space that can have a countable number of dimensions. Scientists called this new structure a Hilbert space. The elements of the orthomodular lattice correspond to the closed subspaces of the vector space. They are certainly not logical statements. Together they span the whole Hilbert space. The Hilbert space has as an additional feature that the internal product of two vectors produces a number that can be used to form linear combinations of vectors that become part of the vector space. In the number system that fits, must any number that is not equal to zero own a unique inverse. There are only three number systems that meet this requirement. These are the real numbers, the complex numbers, and the quaternions [1]. This requirement immediately imposes a firm restriction on extending the orthomodular lattice to a more complicated structure. This kind of constraint is what we seek when the foundation evolves to a higher level.

Mechanisms that map a Hilbert space onto itself are called operators. If the operator maps a normalized vector along itself, then the inner vector product of the vector pair produces an associated eigenvalue. The vector in question is the corresponding eigenvector. Quaternions prove to be an excellent storage bin for the combination of a time stamp and a three-dimensional location. The by Hilbert discovered structure proves to be a very flexible repository for dynamic geometric data of point-shaped objects. The operators are the administrators of these storage bins.

The extension to the Hilbert space is only a first step. Quaternionic number systems exist in many versions that differ in the way that Cartesian and polar coordinate systems can organize these number systems. This fact means that in a single underlying vector space a whole range of Hilbert spaces can be applied, with the corresponding versions of the number systems floating over each other. Each Hilbert space has a parameter space with its own set of coordinates systems. The version of the number system fills the parameter space with its numbers. A reference operator manages the parameter space as its eigenspace. That eigenspace only contains the rational members of the selected version of the number system. We will use the fact that the private parameter spaces float over a selected background parameter space to introduce the idea that the corresponding separable Hilbert spaces float over the background separable Hilbert space. We will call these Hilbert spaces floating platforms. One of the platforms acts as a background and thus provides the background parameter space. This procedure allows a huge number of floating platforms. Soon we will introduce a way to allow only a small set of tolerated platform types.

By using the parameter space and a quaternionic function, the model can define a new operator. This new operator uses the eigenvectors of the reference operator and utilizes the function values as the corresponding eigenvalues. This procedure connects the operator technology of the Hilbert space to the quaternionic function theory. This base model is a powerful tool to model quantum systems.

It is possible to choose a real progression value and connect this value to the subspace corresponding to the background reference operator's eigenvectors whose real part of the eigenvalue corresponds to this progression value. The chosen progression value now divides the obtained model into a historical part and a future part. The separated subspace represents the current status quo of the model. This result means that ordering the real parts of the eigenvalues of operators creates a dynamic model.

The separable Hilbert spaces, which have a countable dimension, support only operators with a countable eigenspace. These eigenspaces can only contain sets of rational eigenvalues. This can be rational quaternions. Each infinite dimensional countable Hilbert space possesses a unique non-countable companion Hilbert space that embeds his countable partner. The non-countable Hilbert space contains operators that possess eigenspaces which are not countable. These eigenspaces form continuums and are mathematically synonymous with fields. Quaternionic functions can describe these fields and continuums. The parameter spaces of these functions are flat continuums.

This structure is starting to become quite complicated but still contains very little dynamism. Only platforms that can float over each other form the so far conceived dynamic objects. Still, the structure constitutes a powerful base platform for modeling the structure and the behavior of physical reality.

3 Meeting

In this base model arise already agreements with the structure that conventional physics has discovered. The base model acts as a storage space for dynamic geometric data. Dynamics can occur if this storage space contains data that after sorting the timestamps tells a dynamic story. The model then tells the tale of a creator that at the time of creation fills the countable Hilbert spaces with dynamic geometric properties of his creatures. However, after the creation, the creator leaves his creatures alone. This result is an astonishing conclusion.

Conventional physics has discovered elementary particles. In fact, they are elementary modules because together they compile all the modules that occur in the universe and some modules form modular systems. The elementary modules appear to live on the floating platforms. They inherit the properties of their platform. The symmetry of the platform determines the intrinsic properties of the platform. At each new progression instant, the elementary particle gets a new location. How this exactly happens is not immediately clear, but the findings of conventional physics give a clue. The elementary particle possesses a wavefunction, which suggests that a stochastic process generates the locations. If this is true, then the elementary particle hops through a hopping path, and after some time, the landing locations form a landing location swarm. This swarm possesses a location density distribution, which is equal to the square of the modulus of the wavefunction. The elementary particle is thus represented by a private platform, by a stochastic process, by a hopping path, by a dense and coherent landing location swarm and by its wavefunction. A dedicated operator stores step by step the life story of the elementary particle in its eigenspace. In the overall story of the model, this life story is embedded step by step into a continuum eigenspace of an operator that resides in a non-separable Hilbert space, which is the companion of the background platform.

As for the elementary particles, the two approaches, therefore, match well. Apart from that, the quaternionic differential theory proves to deliver a great agreement with the equations that Maxwell and others found through interpretations of the results of experiments. Apart from the Maxwell equations, other basic fields exist that obey the quaternionic field equations. An example is our living space. The quaternionic differential calculus explains in deep detail how the fields respond to point-like artifacts. The hop landing locations implement the point-like artifacts. The field responds with a spherical shock front, which then integrates into a small volume. Mathematicians call the shape of this volume the Green's function of the field. Due to the dynamics of the shock front, the plop spreads all over the field. In summary, each hop landing causes a small deformation that quickly fades away. The hop landing also expands the volume of the field a little bit. The stochastic process ensures that the plops partly overlap each other in space and in time. This story explains why the elementary particle constantly deforms its living space and why the particle possesses a quantity of mass. At the same time, the story explains the origin of gravitation and makes clear that the hop landings expand the universe. The Green's function blurs the location density distribution, and the result equals the contribution of the elementary particle to the local gravitation potential.

It appears that both approaches can complement or correct each other.

> Observations and measurements cannot uncover everything. Only the application of deduction can expose the parts of the physical reality that resist observation. The interplay of measurements and deduction can bring about the necessary confidence. The requirement put by some scientists that experiments must verify everything is absolute nonsense. Much of the physical reality is inaccessible to measurement. In that case, deduction remains the only way of approach.

4 How gravitation works

By applying the sketched approach, this section explains in more detail how gravitation works.

4.1 Quaternionic differential calculus

A quaternion can store a time-stamp in its real part and a three-dimensional spatial location in its imaginary part. The quaternionic nabla ∇ acts as a quaternionic multiplying operator. Quaternionic multiplication obeys the equation

$$c = c_r + \vec{c} = ab = \left(a_r + \vec{a}\right)\left(b_r + \vec{b}\right) = a_r b_r - \left\langle \vec{a}, \vec{b} \right\rangle + a_r \vec{b} + \vec{a} b_r \pm \vec{a} \times \vec{b} \tag{4.1.1}$$

The $\pm$ sign indicates the freedom of choice od the handedness of the product rule that exist when selecting a version of the quaternionic number system. The first order partial differential follows from

$$\nabla = \left\{ \frac{\partial}{\partial \tau}, \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right\} = \nabla_r + \vec{\nabla} \tag{4.1.2}$$

$$\phi = \nabla \psi = \left(\frac{\partial}{\partial \tau} + \vec{\nabla} \right)\left(\psi_r + \vec{\psi}\right) = \nabla_r \psi_r - \left\langle \vec{\nabla}, \vec{\psi} \right\rangle + \nabla_r \vec{\psi} + \vec{\nabla} \psi_r \pm \vec{\nabla} \times \vec{\psi} \tag{4.1.3}$$

The differential $\nabla \psi$ describes the change of field ψ . The five separate terms in the first order partial differential have a separate physical meaning. All basic fields feature this decomposition. The terms represent new fields.

$$\phi_r = \nabla_r \psi_r - \left\langle \vec{\nabla}, \vec{\psi} \right\rangle \tag{4.1.4}$$

$$\vec{\phi} = \nabla_r \vec{\psi} + \vec{\nabla} \psi_r \pm \vec{\nabla} \times \vec{\psi} = -\vec{E} \pm \vec{B} \tag{4.1.5}$$

4.2 Field excitation

Gravitation is an interaction between a discrete object and a field that gets deformed by the interaction.

First, we focus on the tiniest interaction. It is a pulse response of a point-like actuator [2]. These pulse responses are solutions of one of two quaternionic second order partial differential equations.

$$\varphi = \left(\frac{\partial^2}{\partial \tau^2} - \left\langle \vec{\nabla}, \vec{\nabla} \right\rangle \right) \psi \tag{4.2.1}$$

$$\rho = \left(\frac{\partial^2}{\partial \tau^2} + \left\langle \vec{\nabla}, \vec{\nabla} \right\rangle \right) \psi \tag{4.2.2}$$

The first of the two second-order partial differential equations is the quaternionic equivalent of the well-known wave equation. The other second order partial differential equation divides into two first order partial differential equations.

$$\rho = \nabla^* \nabla \psi = \nabla^* \phi = \left(\nabla_r - \vec{\nabla}\right)\left(\nabla_r + \vec{\nabla}\right)\left(\psi_r + \vec{\psi}\right) = \left(\frac{\partial^2}{\partial \tau^2} + \left\langle \vec{\nabla}, \vec{\nabla} \right\rangle \right) \psi \tag{4.2.3}$$

Equation (4.2.2) does not support waves as its solutions.

Integration over the time domain results in the Poisson equation

$$\rho = \langle \vec{\nabla}, \vec{\nabla} \rangle \psi \tag{4.2.4}$$

A very special solution of this equation is the Green's function $\frac{1}{\vec{q} - \overrightarrow{q'}}$ of the affected field

$$\nabla \frac{1}{\vec{q} - \overrightarrow{q'}} = -\frac{(\vec{q} - \overrightarrow{q'})}{|\vec{q} - \overrightarrow{q'}|^3} \tag{4.2.5}$$

$$\langle \vec{\nabla}, \vec{\nabla} \rangle \frac{1}{|\vec{q} - \overrightarrow{q'}|} \equiv \left\langle \vec{\nabla}, \vec{\nabla} \frac{1}{|\vec{q} - \overrightarrow{q'}|} \right\rangle = -\left\langle \vec{\nabla}, \vec{\nabla} \frac{(\vec{q} - \overrightarrow{q'})}{|\vec{q} - \overrightarrow{q'}|^3} \right\rangle = 4\pi\delta(\vec{q} - \overrightarrow{q'}) \tag{4.2.6}$$

4.3 Isotropic actuator

If a quaternion is embedded in a field, while its symmetry is incompatible with the symmetry of the embedding field, then the quaternion belongs to a different version of the quaternionic number system than the version that constitutes the background parameter space. A quaternionic function that applies the background parameter space defines the embedding field. Thus, the embedded quaternion breaks the symmetry of the embedding field. Therefore, the embedding will cause a pulse response of the affected field. Only versions of the quaternionic number system that cause an isotropic symmetry breaking can produce the trigger that will actuate a spherical pulse response.

During embedding, most elementary particles break the symmetry. Neutrinos do not break the symmetry, instead they appear to cause a different kind of disparity. They apply a discrepant handedness of the vector product.

For an isotropic actuator, the Green's function is the static pulse response of the field. It is the time integral over the corresponding single shot pulse response of the field. This dynamic pulse response is a solution of a homogeneous second order partial differential equation. The quaternionic equivalent of the wave equation offers the spherical pulse response

$$\psi = \frac{f(r \pm \tau)}{r} \tag{4.3.1}$$

The other second order partial differential equation offers the spherical pulse response

$$\rho = \frac{f(\vec{r} \pm \tau)}{r} \tag{4.3.2}$$

For this equation, the imaginary vector $\vec{r}$ points along the radius. At least it points perpendicular to the direction of movement of the front of the pulse response.

The Green's function has some volume. The volume that the dynamic pulse adds to the field quickly spreads over the full extent of the field. Thus locally, the pulse response deforms the field, and this deformation quickly fades away. However, globally the injected volume is added to the field.

This solution is a spherical shock front. During travel, the shape f of the front stays constant, but its amplitude diminishes as 1/r with distance r from the trigger location.

These interactions are so tiny, and the deformation vanishes so quickly that no observer can ever perceive the effect of a separate spherical pulse response. This statement does not mean that huge ensembles of pulses cannot cause a noticeable effect. Elementary particles demonstrate it for spherical shock fronts.

4.4 Ensembles of spherical shock fronts

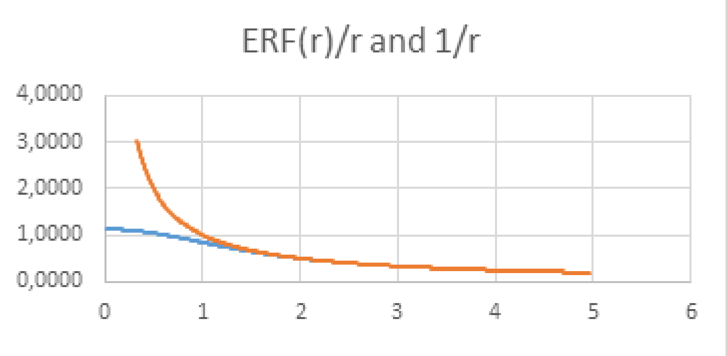
Recurrently regenerated dense and coherent swarms of hop landing locations create the overlap conditions that cause persistent and significant deformation of the field that embeds the hop landings. A stochastic process that generates the subsequent hop landing locations in a hopping path of a point-like object can generate such a condition. At every subsequent instant, the process generates a new hop landing location. This location together with its time-stamp archives in an eigenvalue of a dedicated operator that resides in the separable Hilbert space. The swarm must be coherent. It contains a huge number of elements. These conditions can be ensured if the stochastic process owns a characteristic function and a high efficiency. The characteristic function is the Fourier transform of the location density distribution that describes the swarm. The hopping path stays within the realm of the platform on which the particle resides. Thus, the stochastic hopping path is closed. This means that the hop landing location swarm is recurrently regenerated.

The platform floats over the background platform. Thus, the image of the swarm on the background parameter space moves as a single unit. This can be represented by a displacement generator that is attached as a gauge factor to the characteristic function of the stochastic process, which recurrently regenerates the swarm. It means that on the embedding field the hopping path is not closed. It is closed on the platform on which the elementary particle resides. With other words, the platform, the stochastic process with its characteristic function, the hopping path, the hop landing location swarm, and the location density distribution represent the point-like object that both hops around and moves smoothly as a single object. The object is an ***elementary particle***. The squared modulus of its wavefunction equals the location density distribution of the swarm. The characteristic function acts as a wave package that is continuously regenerated. Usually moving wave packages disperse, but this one keeps being regenerated. Consequently, the object combines particle behavior with wave behavior. The hop landing location swarm can simulate interference patterns. The hop landing locations cause spherical shock fronts that integrate into a Green's function. The Green's function blurs the location density distribution. The result is the convolution of the Green's function with the location density distribution. This result is the contribution of the elementary particle to the local gravitation potential.

If, for example, the location density distribution of the swarm equals a Gaussian distribution, then

$$\frac{ERF(r)}{r} \tag{4.3.3}$$

describes the shape of the gravitation potential of the elementary module. This curve is a perfectly smooth function. At a small distance from the center, the gravitation potential gets the familiar $\frac{1}{r}$ shape.



At some distance from the geometric center of the platform the gravitation field equals

$$\frac{m}{r} \tag{4.3.4}$$

Back-reasoning explains that the spherical shock fronts possess a mass capacity. The degree of overlap determines the value of the mass capacity. The pulse responses contribute part of that capacity to the mass of the elementary particle. In other words, the mass of the elementary particle is proportional to the number of elements of the hop landing location swarm. The notion of mass capacity can be used to explain the existence of multiple generations of elementary particles. The exploited part of the capacity determines the mass generation capacity.

If the geometric center of the swarm and the geometric center of the platform coincides, then at some distance of the geometric center, apart from a multiplication factor, the gravitation potential of the swarm and the Green's function of the symmetry-related field will overlap. In that case the gravitation potential and the potential of the symmetry-related field couple into a single simple equation.

$$(\nabla - eA)\varphi = m\varphi \tag{4.3.5}$$

In atoms, the geometric centers of the platforms of the electrons and the geometric center of their swarm do not coincide. So there this simple equation does not fit.

5 Particle platform

Elementary particles exist in a small number of types. The description of elementary particles in this document says nothing about the fact that several generations of elementary particles exist and that for every type and generation the mass and thus the number of elements of the swarm is fixed. Only a suggestion is given that mass capacity can explain the existence of generations.

The elementary particle inherits many properties of the platform on which it resides. Every elementary particle exploits a private separable Hilbert space, and this platform exploits a private version of the quaternionic number system. This version determines the symmetry-related properties of the platform. For that reason, the platform features symmetry related charges that locate at the geometric center of the platform. The charges correspond to contributions to a symmetry-related field. In free space, the geometric center of the platform couples the gravitation field and the symmetry-related fields.

The stochastic processes apply a target center for the generated distribution. In atoms, the target center of the hop landing location swarm of the electrons oscillates with respect to the geometric center of the platform of the electron. The average location of the target center coincides with the geometric center of the platform. The chapter on modules explains these facts.

5.1 Short-list

The short-list of electric charges that the elementary particles in the standard model appear to possess can only be explained when the number of types of floating platforms is drastically restricted. Floating platforms are only tolerated when the coordinate axes of their private version of the number system are aligned in parallel with the coordinate axes of the background parameter space. This restriction makes possible that the embedding mechanism can decide what the difference is in symmetry between the floating platform and the background platform. The short-list of electric charges in the Standard Model is $-1, \frac{-2}{3}, \frac{-1}{3}, 0, \frac{+1}{3}, \frac{+2}{3}, +1$. The fractional charges belong to quarks. Quarks also possess color charge.

5.2 Symmetry flavor

The Cartesian ordering of its private parameter space determines the symmetry flavor of the platform. For that reason, this symmetry is compared with the reference symmetry, which is the symmetry of the background parameter space. Four arrows indicate the symmetry of the platform. The background is represented by:

↑↑↑↑

Now the symmetry-related charge follows in three steps.

1. Count the difference of the spatial part of the symmetry of the platform with the spatial part of the symmetry of the background parameter space.
2. If the handedness changes from **R** to **L**, then switch the sign of the count.
3. Switch the sign of the result for anti-particles.

Symmetry flavor

Ordering x y z τ	sequence	Handedness Right/Left	Color charge	Electric charge * 3	Symmetry type.
↑↑↑↑	0	**R**	N	+0	neutrino
↓↑↑↑	1	**L**	R	−1	down quark
↑↓↑↑	2	**L**	G	−1	down quark
↓↓↑↑	3	**L**	B	−1	down quark
↑↑↓↑	4	**R**	B	+2	up quark
↓↑↓↑	5	**R**	G	+2	up quark
↑↓↓↑	6	**R**	R	+2	up quark
↓↓↓↑	7	**L**	N	−3	electron
↑↑↑↓	8	**R**	N	+3	positron
↓↑↑↓	9	**L**	R	−2	anti-up quark
↑↓↑↓	10	**L**	G	−2	anti-up quark
↓↓↑↓	11	**L**	B	−2	anti-up quark
↑↑↓↓	12	**R**	B	+1	anti-down quark
↓↑↓↓	13	**R**	R	+1	anti-down quark
↑↓↓↓	14	**R**	G	+1	anti-down quark
↓↓↓↓	15	**L**	N	−0	anti-neutrino

The suggested particle names that indicate the symmetry type are borrowed from the Standard Model. In the table, compared to the standard model, some differences exist with the selection of the anti-predicate. All considered particles are elementary fermions. The freedom of choice in the polar coordinate system might determine the spin. The azimuth range is 2π radians, and the polar angle range is π radians. Symmetry breaking means a difference between the platform symmetry and the symmetry of the background. Neutrinos do not break the symmetry. Instead, they may cause conflicts with the handedness of the multiplication rule.

6 Modules

Elementary particles are elementary modules. Together the elementary modules configure all other modules, and some of the modules constitute the modular systems that occur in the universe.

Like with elementary modules, a stochastic process generates the footprint of modules. The characteristic function of this process equals a dynamic superposition of the characteristic functions of the components of the module. The superposition coefficients act as internal displacement generators and determine the internal positions of the components. The characteristic function of the module also attaches to a gauge factor that acts as a displacement generator, such that the module moves as a single unit. Therefore, the stochastic process of the module binds the components of the module. The footprint generates a swarm of spherical shock fronts that together deform the embedding field. This deformation determines the contribution of the module to the local gravitation potential. The deformation supports the binding of the components.

6.1 Symmetry breaking

During embedding, electrons implement isotropic symmetry breaking. Thus, for electrons, the embedded quaternions can easily create spherical shock fronts that pump volume into the field and deform this carrier.

Neutrinos are formed by quaternions that may differ only by their handedness from the embedding field. They do not feature electric charge or color charge.

Without extra measures, quarks cannot deform their carrier. The quaternions that are generated by the stochastic processes of the quarks must first be turned into isotropic actuators before they can generate the deformation that helps bind the quarks into hadrons. This might explain the existence of color confinement. Inside hadrons, the conglomerated quarks can obtain mass by causing swarms of spherical shock fronts that pump volume into the embedding field. The superposed quaternions constitute the isotropic actuators that trigger the spherical pulse responses.

6.2 Bosons

Elementary fermions fit well as elementary modules. However, elementary bosons, such as W_+, W_- and Z seem not well fit to compose higher level modules. Still, the embedded quaternions cause the spherical pulse responses that deform the embedding carrier field. Photons are considered to be bosons, but they are no elementary particles.

7 The role of volume

A local deformation corresponds to a local extension of the volume of the embedding field. A global extension of the volume corresponds to the expansion of the universe that the field represents. Deformations tend to fade away by spreading over the complete field. The stochastic processes must keep pumping new deformations to ensure that a deformation becomes persistent.

The deformation volume increases faster than the overall volume. The space between the swarms becomes relatively smaller. As a result, the swarms seem to attract each other.

7.1 Mass inertia and gravity

From a larger distance, the gravitational potential of a module has the form of the well-known classical gravitation potential of point-like massive objects $\frac{m}{r}$. Apart from the factor m, this is like the form of the Green's function of the embedding field. We miss the gravitational constant G that takes care of physical units. If the module moves uniformly with speed $\vec{v}$, then this scalar source function is seen as a vector function $\vec{\xi} = \frac{m\vec{v}}{r}$. The gravitation potential itself is a scalar function $\xi_r = \frac{m}{r}$. If nothing else in the field changes, then an acceleration $\vec{a}$ of the module means that a new term $\dot{\vec{\xi}} = \frac{m\vec{a}}{r}$ is added to the change of the vector field $\vec{\zeta}$. This new term represents a new field that counteracts the acceleration. This explains the mass inertia of accelerating objects. Here's a more detailed explanation.

Mathematically, the statement that in first approximation nothing in the field $\vec{\zeta}$ changes indicates that locally, the first order partial differential $\nabla\vec{\xi}$ will be equal to zero.

$$\zeta = \nabla\xi = \nabla_r\xi_r - \left\langle\vec{\nabla},\vec{\xi}\right\rangle + \vec{\nabla}\xi_r + \nabla_r\vec{\xi} \pm \vec{\nabla}\times\vec{\xi} = 0 \qquad (4.3.6)$$

The terms that are still eligible for change must together be equal to zero. These terms are.

$$\nabla_r\vec{\xi} + \vec{\nabla}\xi_r = 0 \qquad (4.3.7)$$

Here plays $\vec{\xi}$ the role of the vector field and ξ_r plays the role of the gravitational potential of the module. If the relative speed $\vec{v}$ is constant, then both terms equal zero. In addition

$$\vec{\xi} = \vec{v}\xi_r \qquad (4.3.8)$$

Uniform acceleration $\vec{a} = \dot{\vec{v}}$ of the module gives a new vector field $\nabla_r\vec{\xi}$ that shows the mass inertia of the module. According to the equation (4.3.7), the new field terms obey:

$$\nabla_r\vec{\xi} = \dot{\vec{v}}\xi_r = -\vec{\nabla}\xi_r = \frac{m\vec{r}}{|r|^3} \qquad (4.3.9)$$

Factor m represents the mass of the module. When two modules move relative to each other with uniform velocity v and then accelerate relative to each other, the mass inertia explains the gravity force that arises between the modules.

$$\vec{F}\left(\vec{r}_1 - \vec{r}_2\right) = \frac{m_1 m_2\left(\vec{r}_1 - \vec{r}_2\right)}{\left|\vec{r}_1 - \vec{r}_2\right|^3} \qquad (4.3.10)$$

The perceived mutual acceleration takes place because space deforms and expands. ***Without space expansion, the force would not exist.*** A similar reasoning as is given here for the classic gravitation potential, also holds for the Coulomb force.

7.2 First inflation

This explanation sheds an interesting light at the beginning of the history of the universe. On that instant, the stochastic processes still had no work done. The balloon of the universe was still empty, and the quaternionic function that describes the universe was equal to its parameter space. It took a full generation cycle of the elementary particles to pump some volume in the balloon. In advance the balloon was flat. The activity of the stochastic processes is distributed evenly over the whole parameter space. The pump action of the first cycle raised the balloon over Its full extent. From that moment on, the volume grows almost isotropic. With the injected volume the distance between the geometric centers of the floating platforms, which are the activity centers of the stochastic processes grows. This differs from the idea of a Big Bang in which everything starts at a single singularity.

7.3 Black holes

Black holes represent the densest packaging of entropy. This qualification might translate into the densest packaging of the pulses that generate spherical shock fronts. A surface through which shock fronts cannot pass encapsulates the region that contains this highest density packaging. The total mass of this region equals the area of the encapsulating surface.

8 One-dimensional actuator

A one-dimensional single shot actuator generates a one-dimensional shock front.

8.1 Solutions

The quaternionic equivalent of the wave equation offers the one-dimensional pulse response

$$\psi = f\left(r \pm \tau\right) \tag{8.1.1}$$

The other second order partial differential equation offers the one-dimensional pulse response

$$\rho = f\left(r \pm \vec{i}\,\tau\right) \tag{8.1.2}$$

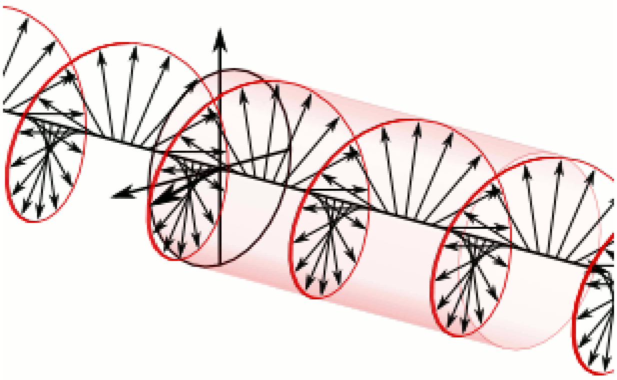
For this equation, the imaginary vector $\vec{i}$ points perpendicular to the direction of movement of the front of the pulse response. This vector implements the polarization of photons. The emitter controls the polarization.

During travel, the front keeps its shape as well as its amplitude. The one-dimensional shock front does not integrate into a volume. Therefore, it does not deform the affected field.

These interactions are so tiny that no observer can ever perceive the effect of a separate pulse response. This statement does not mean that huge ensembles of pulses cannot cause a noticeable effect. Elementary particles demonstrate it for spherical shock fronts. Photons prove it for one-dimensional pulse responses.

8.2 Photons

A long string of equidistant one-dimensional shock fronts can implement the functionality of a photon. The Einstein-Planck relation $E = h\nu$ means that one-dimensional shock fronts represent a standard amount of energy. These shock fronts own an amount of energy, but they do not own mass. The string has a fixed emission duration. This duration relates to the Planck constant.



In the animation of this left handed circular polarized photon, the black arrows represent the moving shock fronts. The red line connects the vectors that indicate the amplitudes of the separate shock fronts. Here the picture of an EM wave is borrowed to show the similarity with EM waves. However,

photons are not EM waves!

8.3 Light

Light beams are known to behave like wave packages. That does not mean that photons themselves are waves. Photons are discrete one-dimensional objects. They are strings with a fixed spatial length. They follow the deformation of their carrier. Their emitters generate a probability wave of photons. That swarm behaves like a wave package. The photons behave as discrete objects. The probability distribution may cover detection location, angular direction, and particle energy. A stochastic process that owns a characteristic function generates the distribution of the photons.

In imaging systems, the Optical Transfer Function, which is the Fourier transform of the Point Spread Function qualifies the imaging performance. Linearly coupled imaging devices may each own a separate Optical Transfer Function. The OTF of the combination equals the product of the OTF's of the composing devices. However, this simple rule holds for monochromatic light that is either coherent or inhomogeneous.

9 Stochastic control of the universe

All elementary modules reside on a private platform that a private separable Hilbert space establishes. That Hilbert space applies a private parameter space that the elements of a version of the quaternionic number system constitute. This version determines the symmetry-related properties of the platform, and the elementary particle inherits these properties. At each subsequent instance, a private stochastic process generates a new hopping path location on this platform. A characteristic function ensures the coherence of the generated hop landing location swarm. The location density distribution of the swarm equals the Fourier transform of the characteristic function, and it equals the squared modulus of the wavefunction of the elementary module. The characteristic function attaches to a gauge factor that acts as a displacement generator that controls the displacement of the platform. Consequently, the swarm moves as a single unit. This rather smooth movement implicates that the activity of the stochastic process can be described by a Lagrangian and the corresponding Hamilton equations [3].

The stochastic process is the combination of a genuine Poisson process and a binomial process. A spatial point spread function that equals the location density distribution of the swarm implements the binomial process.

Together, the elementary modules constitute all modules that occur in the universe. Each composite module owns a stochastic process that possesses a characteristic function, which equals a superposition of the characteristic functions of the components of the module. The dynamic superposition coefficients act as displacement generators for the internal locations of the components. The overall characteristic function attaches to a gauge factor that acts as a displacement generator of the composite module. This fact means that the overall characteristic function binds the components of the module such that in a first approximation the module moves as a single unit.

The superposition coefficients must be selected such that they keep the components together and such that the fermions do not take identical locations. This condition is ensured when the locations oscillate in distinct trajectories. For example, in atoms, the electrons oscillate as different solutions of the Helmholtz equation, which is a time-independent form of the wave equation [4].

Inside the atom, the platforms of the electrons do not take part in the oscillations. Therefore, the electric charges of the electrons do not emit EM waves. Only the target centers of the swarms of the electrons follow the trajectories of the oscillations. The target center is the operational geometric center of the swarm that the statistical process is planning to produce. Thus, not the swarm is oscillating, but its planned center location oscillates.

Only the switch to another oscillation trajectory of the planned swarm center causes the emission or absorption of a corresponding photon. This mode change concerns the behavior of the stochastic process, and the change of the oscillation is a consequence. The emission and the absorption of photons feature a fixed duration. This duration requires a fixed location during that emission. Otherwise, the photon loses its integrity. The location of the photon emission coincides with the geometric center of the atom. The absorption can be considered as a time reversal of an emission. Otherwise, the absorption requests an incredible aiming precision of the impinging photon. The creator's view supports time reversal. Observers cannot properly interpret the absorption.

The nucleus is a conglomerate of elementary particles that locates at the geometric center of the atom. If oscillations regulate the coherence and the binding within the nucleus, then this will be a very complicated construct that controls a hierarchy of submodules. Nuclei constitute the nucleus, and these nuclei are hadrons. Nuclei can be protons or neutrons. Hadrons can be baryons or mesons. Only baryons appear in the nucleus of an atom. The quarks constitute hadrons, and gluons play a role in the binding of quarks. Color confinement prohibits that quarks stay stable in isolation.

9.1 Color confinement

The HBM does not offer a detailed explanation of the binding within the nucleus. However, color confinement may be due to the fact that a pulse that results in a spherical shock front can only be actuated by the embedding of quaternions that break the symmetry of the affected field in a purely isotropic way. Electrons do that automatically. Quarks must first be corrected by a mechanism that corrects their anisotropy. Special quaternion combinations can perform the conversion of a distribution of quaternions into a suitable symmetry flavor. Different types of quarks must be combined to achieve a colorless result. Contemporary physics applies gluons to explain the binding of quarks.

9.2 Force carriers

The description in this document does not apply forces and force carriers. Instead, it applies stochastic processes that own characteristic functions. Explaining binding via force carriers, requests explaining what generates these carriers. The Hilbert Book Model does not explain the origin of the stochastic processes. The model relates the stochastic processes to the embedding process. Similarly, contemporary physics does not explain the origin of the wavefunction.

9.3 Entanglement

The fact that the stochastic process of composite modules has a characteristic function, which is the superposition of the characteristic functions of the components is a generally valid principle. Further, the superposition excludes components that share the same state. Thus, the superposition principle cooperates with an exclusion principle. Objects that take part in the same superposition cannot share the same state. So, in the selection of the components only exclusive components are selected. Also, if one of the components changes its state, then the regeneration of the components must correct the exclusivity by adapting the state of a corresponding object that takes part in the superposition. The regeneration switch occurs at a single progression instant. The stochastic processes of the components perform the regeneration. Only properties that the stochastic processes determine are affected. Thus, electric charges and color charges are not affected. The platforms on which the generated location swarms reside determine these untouched properties. Platforms and fields are not regenerated.

Usually, modules confine to a restricted spatial region. However, the superposition principle that is active between the characteristic functions of the private stochastic processes does not pose spatial restrictions in configuration space. Still, the exclusion of similar states acts over the full module. Thus, if the characteristic function determines properties that determine the state of the corresponding component, then changing the property affects the superposition of the module. Involved properties are spin, polarization, and momentum.

The Hilbert Book Model signals that the superposition principle is active inside modules and that it goes together with an exclusion principle. However, the HBM does not explain why these principles reign.

Entanglement also occurs in superpositions of photons. In that case, the entanglement affects their polarization.

10 Nature's basic dark quanta

The shock fronts represent nature's basic dark quanta. In isolation, they cannot be detected by any instrument. Their effect is too tiny, and for spherical shock fronts the effect is also too temporarily. Their effect becomes noticeable when they join their act in huge numbers. Photons and elementary particles are examples of such cases. However, large halos around massive objects that cause gravitational lensing indicate that huge quantities of spurious spherical shock fronts can produce measurable effects. Already the massive objects themselves create a gravitational lensing effect, but the dark quanta increase that effect. In addition, huge clouds of dark quanta can create gravitational effects on their own.

11 Discussion

Everything that happens to discrete objects archives in the read-only repository. These objects can only interact via fields. The embedding field acts as the living space of the discrete objects. Embedding causes deformation of the living space. Also, may each elementary module give rise to interaction with the symmetry-related fields. The involved symmetry related charges reside at the geometric centers of their platform. The one-dimensional shock fronts transfer bits of energy between the modules. This act changes the potential energy or the kinetic energy of the module. Spherical shock fronts cause two effects. One is a temporary local deformation of the field. The other is a persistent expansion of the volume of the field. Only in huge ensembles that are recurrently regenerated such that the spherical pulse responses at least partly overlap both in time and in space, the volume infusion can result in a persistent deformation. This insight differs crucially from the vision of contemporary physics. The universe must expand, otherwise temporary local deformations would not perceive as attractive. The same mechanism that locally pumps volume into the field, will expand that field. The local addition starts spreading over the field. Spherical pulse responses implement the result of the mechanism. The HBM makes stochastic processes responsible for the generation of the spherical symmetry breaking that can add volume to the field. These stochastic processes appear to create mass out of nothing. However, these stochastic processes take their cause from the embedding of a separable Hilbert space into a non-separable Hilbert space. The two Hilbert spaces apply different versions of the quaternionic number system. This results in the wanted symmetry breaking. The separable Hilbert spaces add their content to the embedding non-separable Hilbert space.

The electrons are elementary particles that use a platform that already owns the required spherical symmetry breaking when it is compared to the embedding platform. The same holds for the neutrinos. However, on embedding the electrons break the symmetry. Neutrinos only differ in the handedness of the product rule of their parameter space. Also, the quarks break the symmetry, but they don't do that in an isotropic way.

The Hilbert Book Model postulates that the only field excitation that pumps volume into the affected field is a spherical pulse response [2]. Only an isotropic breaking can trigger a spherical shock front and pumps volume into the embedding field. The fact that quarks feature mass means that a color confinement mechanism exists that turns combinations of quarks into a swarm that contains actuators, which cause spherical pulse responses. These actuators must be colorless.

The characteristic function of the stochastic process of the component already implements coherence and component binding. Observers perceive the persistent deformation as an extra bonding effect. They can interpret the gravitational potential as the cause of an extra binding force.

Observers travel with the subspace that is determined by the progression parameter. Observers can only retrieve data from storage bins that correspond to a historic time stamp. The embedding field transfers this data from the observed event to the observer. Consequently, the observers perceive the data that were archived in the Euclidean format in quaternionic eigenvalues, in spacetime format. The hyperbolic Lorentz transform describes the corresponding coordinate transform. The data is also affected by the deformation of the information path that runs through the embedding field that acts as the living space for the observers. This information path gets deformed by the deformations of the carrier field.

Apart from the observer's view, the model also provides a storage view, which is the view of the creator. The creator can access all archived dynamic geometric data. The view of the creator is a valid view. In that view, creatures don't possess a free will. However, the observer's get the impression that they possess free choice. This impression is supported by the stochastic processes, whose result the read-only repository archives at the instant of creation. This predetermination is hidden from the observers.

References

The Hilbert Book Model Project [5] explores the mathematical foundation of physical reality. An e-print archive [6] contains documents that highlight certain aspects of this project.

[1] https://golem.ph.utexas.edu/category/2010/12/solers_theorem.html

[2] http://www.physics.iitm.ac.in/~labs/dynamical/pedagogy/vb/3dpart2.pdf

[3] https://en.wikiversity.org/wiki/Hilbert_Book_Model_Project/Multi-mix_Path_Algorithm

[4] https://en.wikipedia.org/wiki/Helmholtz_equation#Three-dimensional_solutions

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