THE HILBERT BOOK MODEL GAME

This e-book is still in development phase.

This e-book is the successor of
Physics of the Hilbert Book Model
http://vixra.org/abs/1307.0106
and it is a companion of the YouTube video
http://youtu.be/yUXoN7oF2uQ

Colophon

Written by Ir J.A.J. van Leunen
The subject of this book is a new model of fundamental physics.

This book is written as an e-book. It contains hyperlinks that become active in the electronic version, which is archived at http://vixra.org/author/j_a_j_van_leunen.
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The current model is far from complete.

It will never reach completion.

The human brain is not capable to catch the full extent of the complexity of physical reality.

Preface

I started the Hilbert Book Model project during my studies in physics in the sixties on the Technical University of Eindhoven (TUE).
In the first two years the lectures concerned only classical physics. In the third year quantum physics was introduced. I had great difficulty in understanding why the methodology of doing physics changed drastically. So I went to the teacher, which was an old nearly retired and very wise professor and asked him:
"Why is quantum mechanics done so differently from classical mechanics?".
His answer was short. He stated":
"The reason is that quantum mechanics is based on the superposition principle".

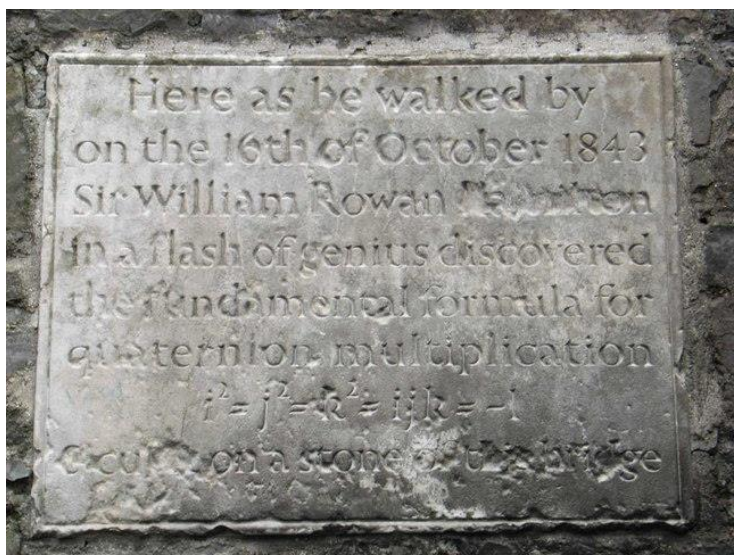
I quickly realized that this was part of the methodology and could not be the reason of the difference in methodology[1]. So I went back and told him my concern. He told me that he could not give me a better answer and if I wanted a useful answer I should research that myself. So, I first went to the library, but the university was quite new and its library only contained rather old sec-

[1] Superposition of particles is an indispensable ingredient in the comprehension of the formation of composites.

ond hand books, which they got as a gift from other institutions. Next I went to the city's book shops. I finally found a booklet from P. Mittelstaedt: (Philosophische Probleme der modernen Physik,
BI Hochschultaschenbücher, Band 50, 1963) that contained a chapter on quantum logic.
It learned me that small particles appear to obey a kind of logic that differs from classical logic. As a result their dynamic behavior differs from the behavior of larger objects, which obey classical logic. I concluded that this produced the answer that I was looking for.
I searched further and encountered papers from Garret Birkhoff and John von Neumann that explained the correspondence between quantum logic and separable Hilbert spaces. That produced a more conclusive answer to my question.
Retrospectively my old professor was partly right. On its own, quantum logic does not provide the answer. The superposition principle also plays a crucial role.

The lectures also told me that observables were related to eigenvalues of Hermitian operators. These eigenvalues are real numbers. However, it was clearly visible that nature has a 3+1D structure. So I tried to solve that discrepancy as well. After a few days of puzzling I discovered a number system that had this 3+1D structure and I called them compound numbers. I went back to

my professor and asked him why such compound numbers were not used in physics. Again he could not give a reasonable answer.
When I asked the same question to a much younger assistant professor he told me that these numbers were discovered more than a century earlier by William Rowan Hamilton when he was walking with his wife over a bridge in Dublin. He was so glad about his discovery that he carved the formula that treats the multiplication of these numbers into the sidewall of the bridge. The inscription has faded away, but it is now molded in bronze and fixed to the same wall by Hamilton's students.



The numbers are known as quaternions. So, I went to the library and searched for papers on quaternions.
In those years Constantin Piron wrote his papers on the number systems that can be used by Hilbert spaces. Piron discovered that only members of suitable division rings can be used as coefficients in linear combinations of Hilbert vectors in separable Hilbert spaces. Later this was affirmed more thoroughly by Maria Pia Solèr. Division rings comprise real numbers, complex numbers and quaternions. That information completed my insight in this subject.
I finalized my physics study with an internal paper on quaternionic Hilbert spaces.

The university was specialized in applied physics and not in theoretical physics. This did not stimulate me to proceed with the subject. Next, I went into a career in industry where I used my knowledge of physics in helping to analyze intensified imaging and in assisting with the design of night vision equipment and X-ray image intensifiers. That put me with my nose on the notion of quanta.
The output window of image intensifiers did not show impinging radiation waves. Instead they showed clouds of impinging quanta. In those times I had not much opportunity to deliberate on that fact. However, after my

retirement I started to rethink the matter. That was the instant that the Hilbert Book Model was revived.

In 2009 at the age of 68 I restarted the Hilbert Book Model project. The HBM is a very simple model of physics that is completely deduced and only covers the lowest levels of fundamental physics. For that reason it is strictly based on a solid foundation. For that foundation I choose the lattice structure of traditional quantum logic. The lattice structure of this logic system is isomorphic to the lattice structure of the set of closed subspaces of a separable Hilbert space.
Since neither the logic system nor the Hilbert space can represent dynamics, a full dynamic model is based on an ordered sequence of such static sub-models. This sequence shows great similarity with the set of pages of a book. This has led to the name "Hilbert Book Model"

Thus, in a few words: The Hilbert Book Model tries to explain the existence of quanta. It does that by starting from traditional quantum logic.

During deliberations in discussion groups on the internet I encountered great resistance against largely or completely deduced theories and models of physics. The Hilbert Book Model is completely deduced.
For that reason I reformatted the project in the form of a game. The game starts at well selected first principles.

From this foundation a model is generated. That model is not presented as a model of physics. However, the target of the game is a model that shows many features and phenomena that resemble features and phenomena that we know from our knowledge that we gathered by observing physical reality. When that target is reached, then it can be discussed whether the produced model represents a useful theory of physics.

You will find the achieved model to be in many aspects controversial and non-conventional. That is why the author took great efforts in order to keep the model self-consistent.

Due to a series of new concepts that are introduced by the HBM and the fact that they lend themselves for a rather pictorial description, will physicists that support conventional physics experience the HBM as a kind of Alice's wonderland. In this manuscript, all of these new concepts will be introduced in a cautious and trustworthy manner. The methodology will directly or indirectly base on the selected foundation.

Some readers have criticized me for lack of formulas, because one formula can say more than a thousand words. Restating formulas that you can find in any physical textbook is not the purpose of this book. On the other hand this manuscript contains formulas that you

will not find elsewhere. An important example is the coupling equation. Another example is the definition of the blurred allocation function. For those who are interested in related formulas the e-paper Q-FORMULÆ contains formulas that are difficult to find in literature.

The main purpose of the Hilbert Book Model is to get insight into the possibilities of the physical toolkit.

Each time that I read this book I encounter small and sometimes big inconsistencies. When I see them I repair them. Due to my sloppy nature there must still be a lot of them left. I apologize to the reader for this inconvenience. I do not consider myself a good and precise mathematician and I consider myself as a horrible physicist. The Great Creator must be a lot better. For a better manuscript you better invite Him. He constructed this structure.

If a mathematical theory is self-consistent, then there is a realistic chance that nature somewhere somehow uses it.

If that theory is compatible with traditional quantum logic, then there is a much larger *chance that nature will use it.*

This drives my intuition.

This manuscript does not offer another physical reality. The Hilbert Book Model offers an alternative view on physical reality.

That view differs from the view that is offered by contemporary physics.

In this way the manuscript can offer new insights.

No model of physics can change physical reality.
Any view on physical reality involves a model.
Drastically different models can still be consistent in themselves.

The Hilbert Book Model is a simple self-consistent model.
This model steps with universe-wide progression steps from one sub-model to the next one. Each of these sub-models represents a static status quo of its universe. The sub-models are strictly based on traditional quantum logic

The HBM is a pure quaternion based model.
Conventional physics is spacetime based and uses complex numbers.
When both models are compared, then the progression quantity
(which represents the page number in the Hilbert Book model)
corresponds to proper time in conventional physics.

In the HBM all proper time clocks are synchronized.
The length of a smallest quaternionic space-progression step in the HBM corresponds to an "infinitesimal" observer's time step in conventional physics.

HvL

Ir J.A.J. van Leunen

THE HILBERT BOOK MODEL GAME

ACKNOWLEDGEMENTS

I thank my wife Albertine, who tolerated me to work days and nights on a subject that can only be fully comprehended by experts in this field. For several years she had to share me with my text processor. She stimulated me to bring this project to a feasible temporary end, because this project is in fact a never ending story.

I also have to thank my friends and discussion partners that listened to my lengthy deliberations on this non society chitchat suitable subject and patiently tolerated that my insights changed regularly.

DETAILS

The Hilbert Book Model is the result of a still ongoing research project.
That project started in 2009.

The continuing status of the project can be followed at
http://www.e-physics.eu

The author's e-print site is:
http://vixra.org/author/j_a_j_van_leunen.
This book is accompanied by a slide show at
The HBM_Game
Use a PowerPoint viewer for this .pptx file
Or the corresponding YouTube video
The_Hilbert_Book_Model_Game

The nice thing about laws of physics is that they repeat themselves. Otherwise they would not be noticed. The task of physicists is to notice the repetition.

Contents

1 Main model differences

In this section we use advanced concepts that will only make sense to experts. However, these concepts will be described and explained in later sections. Also Wikipedia can be taken to the rescue by novices in this field.

The main difference between the models of contemporary physics and the Hilbert Book Model is the fact that the HBM uses a paginated space-progression model where the models of contemporary physics use the spacetime model. The paginated space-progression model features an Euclidean signature and the spacetime model offers a Minkowski signature. In a paginated model progression steps with model wide steps.

Pagination means that at every progression step the whole model can be considered to be recreated. However, this interpretation only holds for the descriptors and storage holders of discrete objects. It need not hold for descriptors and storage holders of continuums. This is due to the fact that the HBM is based on first principles that define a static structure consisting of discrete elements.

Another significant difference is that the HBM focusses on the fine grain structure of particles. This fine grain structure is stored in eigenspaces of operators that reside in the Hilbert space. In contrast the methods of contemporary physics use a smoothed and thus blurred view that is offered by continuous descriptors that store their data in eigenspaces of operators

that reside in the corresponding Gelfand triple. Also the Hilbert space operators that the methods of contemporary physics use retrieve their primary information from the smoothed objects that reside in the Gelfand triple.

A typical example of such smoothed information is the wave function of discrete objects. Further, typical Hilbert space operators are density operators and density matrices. These operators base on smoothed representations of the objects that they describe. The usage of continuous descriptors opens the full toolkit that is based on Lie groups and Lie algebras.

The HBM does not neglect the Gelfand triple and the advantages that is offered by smoothed descriptors. In fact it investigates the fit between the Hilbert space and its Gelfand triple. This fit is ignored by contemporary physics.

Pagination means that Hilbert spaces are recreated at every progression step, while the Gelfand triple survives the recreation. In the HBM, progression steps along Hilbert spaces and flows in the Gelfand triple.

As a result the HBM considers swarms and swarming conditions. These concepts do not occur in contemporary physics. However, the normalized continuous density distribution that offers a smoothed description of the swarm equals the squared modulus of the wave function that is used by contemporary physics.

Thus neither the HBM nor the models of contemporary physics deliver a false view. However, the models of contemporary physics hide the fine grain geometric structure and the corresponding dynamic behavior. In this way the HBM can uncover the origins of phenomena that stay obscure to contemporary physics.

Another main difference between the HBM and contemporary physics is the reliance of the HBM on the quaternionic number system, while the models of contemporary physics uses complex numbers. For the eigenvalues contemporary physics uses real numbers. This has some significant consequences. The HBM cannot use the gauge transformations that are ubiquitously used in contemporary physics. It must find a replacement for that approach. This is found by exploiting superpositions in the Fourier space (momentum space) rather than in the configuration space. However, the symmetry flavors of the quaternionic functions support simple explanation of the couplings of these symmetries that play a role when elementary particles are treated. Contemporary physics must use the combination of spinors and matrices in order to provide descriptions that use complex functions for implementing symmetry dependent behavior. Since the HBM focuses on these fine grain structures the use of quaternions is to its advantage.

Further, the HBM makes an extra mechanism that is external to the Hilbert spaces and external to the Gelfand triple responsible for ensuring dynamic coherence. This mechanism shows great resemblance to an RTOS. It schedules parallel

tasks such that they stay in sync and it keeps care that the model maintains its skeleton relational structure.

Due to the regeneration processes and the necessity to keep everything in sync, the HBM maintains a standard cycle period that holds for the regeneration of its discrete construction elements. This cycle is synchronized with the basic progression step.

The most influential difference between the HBM and contemporary physics is that it explores features and phenomena that can never be observed. The tendency of physicists to always require experimental verification of any significant physical statement forbids them to investigate or reason about facts that can only be deduced. However, these facts can explain other facts that can actually be observed. The HBM project is formatted such that this chance is optimized. With other words, the discoveries of the HBM can be verified indirectly.

2 The game

The Hilbert Book Model project is shaped as an instance of a category of modelling games. This category is characterized by the fact that the game starts with well selected first principles. This foundation is expanded by a trustworthy deduction process such that finally a model is obtained that shows many features and phenomena that we know from physical reality.

The model is shaped in the form of a game because most physicists mistrust completely or largely deduced models.
A completely deduced model endangers to become the victim of the extreme fantasy of the model designer. That is why many physicist are suspicious about completely or largely deduced models and require experimental verification of every relevant physical statement. Often they do not even consider deduced models as a valid scientific approach.

This hampers the serious designers of completely deduced models, because these models withdraw from experimental verification.
One of the counter measures is to base the deduced model on a well-accepted foundation or on smartly selected first principles.

By pretending that we play a game, we cheat the criticizers. We do not call the project a model of physics. Instead we configure the project as a modeling game.
At the advance of the game the model is not considered as a model of physics. If the game succeeds, then the final model will resemble physical reality and that model can be considered as a model of physics.

However, one of the main problems will be the prove of the isomorphism between the aspects of the model and corresponding aspects of physical reality.
In fact contemporary physics encounters the same problem. In contemporary physics this inconsistency is ignored. The success of the application is used as justification. Only philosophers bother about this model mapping problem.

we postpone the discussion whether we produced a model of physics to the end of the game. If the newly generated model uncovers new science, then it has reached its purpose.

3 First principles

3.1 Model creation

The creator of the model must first resolve his most acute problem. He wants to create a universe that resembles physical reality. If he cannot keep complexity within reasonable bounds, then dynamic chaos will result. He is confronted with a very complicated task and he must take measures that this complexity stays within manageable bounds.

3.1.1 What determines complexity?

Complexity depends on the number and the diversity of the relations that exist between objects that play a role in the considered system

Potential relational complexity of a set of objects is a measure that is defined by the number of potential relations that exist between the members of that set.
If there are n elements in the set,
then there exist $n\ (n-1)$ potential relations.

Actual relational complexity of a set of objects is a measure that is defined by the number of relevant relations that exist between the members of the set.

Relational complexity ratio is the ratio of the number of relevant relations divided by the number of potential relations.

3.2 Rules restrict complexity

Physical reality appears to apply restricting rules for relational structures that it accepts. These rules intent to reduce the complexity of these relational structures. The gamer must solve the same basic problems that physical reality encounters. As a consequence he must install similar rules.

3.2.1 Modularization

Modularization is a very powerful influencer.
Together with the corresponding encapsulation it reduces the relational complexity of the ensemble of objects on which modularization works. The encapsulation keeps most relations internal to the module.

3.2.1.1 The basic modularization law

The model is completely deduced. For that reason the model is founded on well selected first principles. In the Hilbert Book Model Game, these first principles are taken from the definition of traditional quantum logic. Quantum logic can be considered as a logic system, but it appears that for application in model generation it can better be considered as part of a recipe for modular construction.

Quantum logic represents a skeleton relational structure that acts as a skeleton for modular construction. In this usage the elements of the skeleton relational structure are not propositions. Instead these elements are building blocks and composites of building blocks.

The HBM keeps the name quantum logic in order to honor its discoverers Garret Birkhoff and John von Neumann that gave the skeleton relational structure its name.

The axioms that define the selected skeleton relational structure of quantum logic are used as the first principles on which the Hilbert Book Model Game will be based. Together these axioms define part of the basic modularization law.

At every progression instant, all discrete constructs in physical reality are supposed to expose the skeleton relational structure that is defined by quantum logic

On itself the skeleton relational structure does not provide a recipe for modular construction. A mechanism that binds building blocks into composites and that encapsulates relations that are internal to the composites must complete the recipe.

Specifying a suitable skeleton relational structure and adding the mechanism can drastically reduce the complexity of a model. For that reason the HBM selects quantum logic as its skeleton relational structure.

These capabilities of the skeleton relational structure become more apparent when the lattice isomorphism between the elements of quantum logic and the set of closed subspaces of an infinite dimensional separable Hilbert space is considered. Via this isomorphism the superposition principle enters the model. The superposition principle is the driving force behind binding building blocks into composites and behind encapsulating relations within that composite.

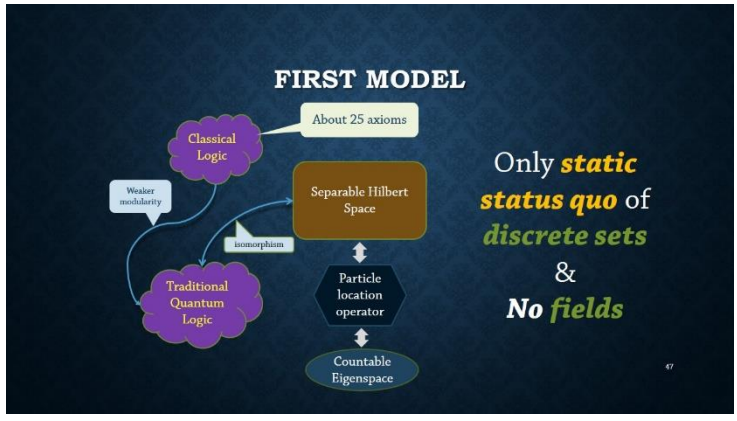
How this is achieved is a delicate process that will be explained in the course of the development of the model. Here we just state that superposition implements the required extra functionality.

The full basic modularization law can be formulated in the realm of this Hilbert space.

At any progression instant, all discrete constructs in physical reality can be represented by a closed subspace of a single separable Hilbert space

This basic modularization law only concerns discrete objects and its describes the situation in a static status quo of the universe.

Now we have a two stage model. The first stage delivers the skeleton relational structure and the second stage adds the superposition principle. However, the two stage model only describes a static status quo and it does not describe continuums.



Further the basic modularization law talks in terms of subspaces. These subspaces are spanned by Hilbert vectors. So, the subspaces contain more detail than the elements of quantum logic.

The first version of our model is very simple and needs extension. Especially the Hilbert vectors that span the subspaces need interpretation. These Hilbert vectors can take the role of eigenvectors of linear operators. What will be the role of the corresponding eigenvalues? They represent the way that ***geometry emerges*** into the model!

Quantum logic and the lattice isomorphism with a separable Hilbert space was uncovered in a paper written by Garret Birkhoff and John von Neumann. In those days it was not discovered that this combination induces a basic modularization law. Instead scientists investigated for decades what the special meaning of the propositions of quantum logic could be.

The number systems that can be used by the separable Hilbert space are confined to members of a suitable division ring. This was already mentioned in the 1936 paper of Birkhoff and von Neumann and was affirmed by Constantin Piron and Maria Pia Solèr in the sixties. It means that the only suitable number systems are real numbers, complex numbers and quaternions.

The eigenvalues of the linear operators introduce geometrical aspects into the model.

Next we will explain the skeleton relational structures and the separable Hilbert spaces in more detail.

4 Skeleton relational structures

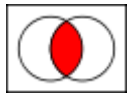
4.1 Quantum logic

Elementary particles behave non-classical. They can present themselves either as a particle or as a wave. A measurement of the particle properties of the object destroys the information that was obtained from an earlier measurement of the wave properties of that object.
With elementary particles it becomes clear that that nature obeys a different logic than our old trusted classical logic. The difference resides in the modularity axiom. That axiom is weakened.
Classical logic is congruent to an orthocomplemented modular lattice.
Quantum logic is congruent to an orthocomplemented weakly modular lattice. Another name for that lattice is orthomodular lattice.

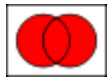
4.1.1 Lattices

A subset of the axioms of the logic characterizes it as a half ordered set. A larger subset defines it as a lattice. A lattice is a set of elements a, b, c, ...that is closed for the connections ∩ and ∪.

∩ is called **conjunction**[2]**.**



∪ is called **disjunction.**



These connections obey:

- The set is partially ordered. With each pair of elements a, b belongs an element c, such that $a \subset c$ and $b \subset c$.
- The set is a ∩ half lattice if with each pair of elements a, b an element c exists, such that $c = a \cap b$.

[2] http://en.wikipedia.org/wiki/Logical_conjunction

- The set is a ∪ half lattice if with each pair of elements a, b an element c exists, such that $c = a \cup b$.
- The set is a lattice if it is both a ∩ half lattice and a ∪ half lattice.

The following relations hold in a lattice:

$$a \cap b = b \cap a \tag{1}$$

$$(a \cap b) \cap c = a \cap (b \cap c) \tag{2}$$

$$a \cap (a \cup b) = a \tag{3}$$

$$a \cup b = b \cup a \tag{4}$$

$$(a \cup b) \cup c = a \cup (b \cup c) \tag{5}$$

$$a \cup (a \cap b) = a \tag{6}$$

The lattice has a partial order inclusion ⊂:

$$a \subset b \Leftrightarrow a \subset b = a \tag{7}$$

A complementary lattice contains two elements n and e with each element a an complementary element a' such that:

$$a \cap a' = n \tag{8}$$

$$a \cap n = n \tag{9}$$

$$a \cap e = a \tag{10}$$

$$a \cup a' = e \tag{11}$$

$$a \cup e = e \tag{12}$$

$$a \cup n = a \tag{13}$$

e is the unity element; n is the null element of the lattice

An orthocomplemented lattice contains two elements n and e and with each element a an element a'' such that:

$$a \cup a'' = e \tag{14}$$

$$a \cap a'' = n \tag{15}$$

$$(a'')'' = a \tag{16}$$

$$a \subset b \Leftrightarrow b'' \subset a'' \tag{17}$$

A distributive lattice supports the distributive laws:

$$a \cap (b \cup c) = (a \cap b) \cup (a \cap c) \tag{18}$$

$$a \cup (b \cap c) = (a \cup b) \cap (a \cup c) \tag{19}$$

A modular lattice supports:

$$(a \cap b) \cup (a \cap c) = a \cap (b \cup (a \cap c)) \tag{20}$$

A weak modular lattice supports instead:

There exists an element d such that

$$a \subset c \Leftrightarrow (a \cup b) \cap c = a \cup (b \cap c) \cup (d \cap c) \tag{21}$$

where d obeys:

$$(a \cup b) \cap d = d \tag{22}$$

$$a \cap d = n \tag{23}$$

$$b \cap d = n \tag{24}$$

$$[(a \subset g) and (b \subset g) \Leftrightarrow d \subset g \tag{25}$$

In an atomic lattice holds

$$\exists_{p \in L} \forall_{x \in L} \{x \subset p \Rightarrow x = n\} \tag{26}$$

$$\forall_{a \in L} \forall_{x \in L} \{(a < x < a \cap p) \Rightarrow (x = a \, or \, x = a \cap p)\} \tag{27}$$

p is an atom

Both the set of elements of quantum logic and the set of subspaces of a separable Hilbert space $\mathbf{H}$ have the structure of an orthomodular lattice. In this respect these sets are congruent.
In Hilbert space, an atom is a pure state (a ray spanned by a single vector).

Classical logic has the structure of an orthocomplemented distributive modular and atomic lattice.

Quantum logic has the structure of an orthomodular lattice. That is an orthocomplented weakly modular and atomic lattice.

The set of closed subspaces of a Hilbert space also has that structure.

4.1.2 Lattice elements

Lattice elements can, but must not be propositions. In logic systems the elements are considered as propositions. This is why the name quantum logic has confused many physicists. For the purpose of model generation the elements of this structure can better be interpreted as modular construction elements.

Thus quantum logic is an exception. It has a treacherous name. It can be considered as a logic system and it can be considered as a skeleton relational structure. In this skeleton relational structure the elements can be interpreted as building blocks and composites of building blocks. With this interpretation the skeleton relational structure can become part of a recipe for modular construction.

4.1.2.1 Propositions

In Aristotelian logic a proposition is a particular kind of sentence, one which affirms or denies a predicate of a subject. Propositions have binary values. They are either true or they are false.
Propositions take forms like "This is a particle or a wave". In mathematical logic, propositions, also called "propositional formulas" or "statement forms", are statements that do not contain quantifiers. They are composed of well-formed formulas consisting entirely of

atomic formulas, the five logical connectives[3], and symbols of grouping (parentheses etc.). Propositional logic is one of the few areas of mathematics that is totally solved, in the sense that it has been proven internally consistent, every theorem is true, and every true statement can be proved. Predicate logic is an extension of propositional logic, which adds variables and quantifiers.
Predicates may accept attributes and quantifiers. The predicate logic is also called first order logic. A dynamic logic can handle the fact that predicates may influence each other when atomic predicates are exchanged.

4.2 Hilbert space

The set of closed subspaces of an infinite dimensional separable Hilbert space is lattice isomorphic with the set of elements of a quantum logic system.

4.3 Hilbert logic

Thus, the set of elements of traditional quantum logic is lattice isomorphic with the set of closed subspaces of a separable Hilbert space. However there exist still significant differences between this logic system and the Hilbert space.

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[3] http://en.wikipedia.org/wiki/Logical_connective

This gap can be closed by refining the specification of quantum logic.

Step 1: Add to each element as an extra attribute a numeric value that gets the name ***relevance factor***.
Step 2: Require that linear combinations of atomic elements also belong to the logic system.
Step 3: Introduce the notion of a ***relational coupling measure*** between two linear elements. This measure has properties that are similar to the properties of the inner product of Hilbert space vectors.
Step 4: Close the subsets of the new logic system with respect to this ***relational coupling measure***.

The relevance factor and the relational coupling measure can have values that are taken from a suitable division ring[4]. The resulting logic system will be called Hilbert logic.

4.4 Similarity with Hilbert space

The addition of the relevance factor installs the superposition principle. A linear combination of linear element is again a linear element.

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[4] The restriction to a division ring is taken from the fact that also Hilbert space restricts its numbers to elements of a division ring.

In this way the Hilbert logic is lattice isomorphic as well topological isomorphic with the corresponding Hilbert space.
Due to this similarity the Hilbert logic will also feature linear operators.
In a Hilbert logic, linear operators can be defined that have linear atoms as their eigen-elements. The eigen-space of these operators is countable. The eigenvalues are numbers that introduce geometry into the model.
Linear elements are the equivalents of Hilbert vectors.
General basic modularization structure elements are the equivalents of (closed) subspaces of a Hilbert space.
The measure of the relational coupling between two linear elements is the equivalent of the inner product between two Hilbert vectors.

4.5 Free elements

The relevance factor can be used to define the notion of free elements.
If the modulus of the relevance factor is maximized at a fixed value, for example unity, then a free element can be defined as an element for which this maximum is reached. It means that free elements cannot be considered as members of a superposition. On the other hand free elements can be superpositions of bounded elements.
When used in this way the relevance factor takes the role of a ***probability amplitude***.

4.6 Binding building blocks and encapsulating their relations.

The superposition principle is the driving force behind the binding of building blocks into composites. Composites are construction elements that can be written as linear combinations of more basic building blocks. Thus, the constituents of composites are not free elements. Instead they are bounded elements. The constituents lose their individuality and the relations in which these constituents play a role become less apparent. With other words, the superposition principle installs the relational encapsulation of the constituents of the composite.

4.7 Restrictions

The skeleton relational structures can only model countable sets of discrete elements. The structures offer no means for modeling continuums.

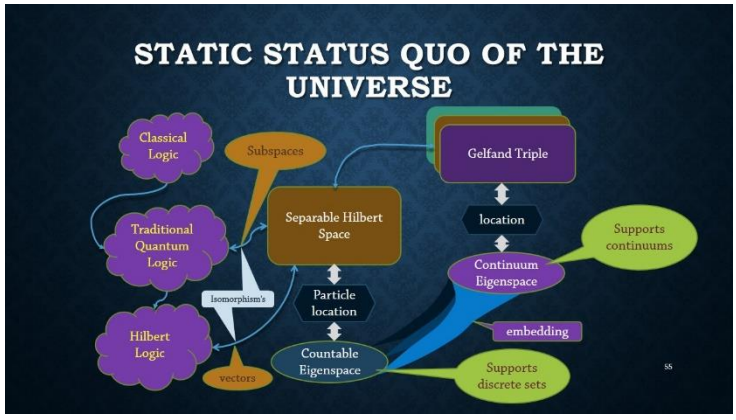
The axioms that define these structures specify relations between the elements. These axioms do not specify the content of the elements.

The axioms do not provide a means to implement dynamics. The skeleton relational structures can only model a static status quo.

These restrictions also hold for separable Hilbert spaces.

5 Modelling continuums

In the sixties Gelfand introduced a way to model continuums via an extension of the separable Hilbert space via a so called Gelfand triple. The Gelfand triple often gets the name rigged Hilbert space, which is confusing, because this construct is not a Hilbert space.
The Gelfand triple offers linear operators that have continuums as eigenspaces. The restrictions that hold for the number systems that can be applied for the separable Hilbert space, also hold for the Gelfand triple.



In this stage the model introduces geometry via the eigenspaces of linear operators and it offers the possibility to embed discrete objects in a continuum.

In this phase the model cannot implement dynamics. Still, like the separable Hilbert space, the Gelfand triple can only represent a static status quo.

5.1 Hilbert space and its Gelfand triple

Start with a separable Hilbert space that contains a normal operator that uses all rational numbers of a selected division ring as its eigenvalues[5].
Take the set of eigenvectors of this operator.
Now define vectors that are linear combinations of these eigenvectors and that have a norm that is equal to unity.
Next take series of such constructs that converge to sets in which all pairs of vectors have inner products, which approach to unity.
Finally close this space such that all limits of the series are included[6].
Now the space includes vectors that are eigenvectors with eigenvectors that are limits of converging series of rational numbers. Thus all real numbers have an eigenvector in the new construct.
Call this new construct the Gelfand triple of the original separable Hilbert space.

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[5] A formal introduction of the Gelfand triple is given: http://en.wikipedia.org/wiki/Gelfand_triple. Here we introduce the Gelfand triple in a different way.
[6] This must be done in ONE single step!

The resulting construct is a vector space that possesses continuum vector spaces.
The construct is the Gelfand triple of the Hilbert space. Sometimes it is falsely called a rigged Hilbert space[7].

The selected operator in the Hilbert space and the corresponding operator in the Gelfand triple are each other's ***brothers***. The eigenvectors of the operator in the Gelfand triple that have rational eigenvalues have a one to one correspondence to the eigenvectors of the brother operator in the separable Hilbert space. Later we use the selected operators as reference operators that deliver flat parameter spaces.

The Hilbert Book Model uses the eigenspaces of these operators as parameter spaces.

[7] A Gelfand triple is NOT a Hilbert space.

6 Modelling dynamics

From observations we know that we live in a dynamical environment. Thus the target model must implement dynamics.

A very simple and efficient way to convert an essentially static model into a dynamic model is the conversion of the model into an ordered sequence of the static sub-models. These static sub-models must slightly differ from each other such that sufficient coherence exists between subsequent members of the sequence, otherwise dynamical chaos will result. On the other hand the coherence must not be too stiff, otherwise no dynamics will take place.

The static sub-models offer no built-in support for ensuring this coherence. This means that the model must be extended with an external mechanism that takes care of the coherence between subsequent steps. This mechanism acts as a kind of ***operating system***.

The resulting model proceeds with model wide steps from each static status quo to the next static status quo. As a consequence a ***model wide clock*** resides in the model that ticks with the highest frequency that can oc-

cur in the model. The clock tick corresponds to a ***progression step*** and its "reading" represents a ***progression parameter.***

The resulting model looks like the set of pages of a book where the progression parameter plays the role of the page number. Each page describes a static status quo of the geometry of the model. The countable eigenspaces of linear operators in the separable Hilbert spaces and the continuum eigenspaces of linear operators in the Gelfand triple act as ***storage places*** for ***geometrical data***.

At each progression step the separable Hilbert space is ***regenerated.*** The Gelfand triple and its operators may survive this regeneration step. This means that progression ***steps*** along separable Hilbert spaces and ***flows*** in the Gelfand triple. This fact is used by the operating system in order to establish the required dynamical coherence between subsequent progression steps.

6.1 Control of dynamics

The models of contemporary physics tend to locate the control of dynamics in features of the Hilbert space or a corresponding function space. The ***Schrödinger picture*** is a name for a category of models that locates dynamic control into the quantum state functions. The ***Heisenberg picture*** is the name for a category of models that

locates dynamic control in the operators that act on these states. The HBM puts the control in the operating system and keeps the results in the storage places that are offered by the eigenspaces.

During the development of the HBM it will become clear that the mentioned operating system is a delicate instrument. It operates “out of sight” and in seclusion as a set of parallel tasks that prepare discrete distributions from which via random selection the active eigenvalues will be selected. The cooperation of these tasks is so complicated that the idea that the functionality of the operating system can be housed in the Hilbert space or in the Gelfand triple is absurd. On the other hand, the tasks of the operating system are strongly influenced and restricted by the necessity to fit the Hilbert space onto its Gelfand triple.

6.2 Paginated space progression model

The resulting model is a paginated space-progression model. Here eigenspaces of a series of linear operators in the Gelfand triple represent what is usually considered as “space”. Another eigenspace acts as a static and flat parameter space that is formed by a quaternionic number system.

This space-progression model features a Euclidean signature. Progression cannot be measured. It proceeds so fast that no observable readings can be provided.
In the paginated space progression model the observer does not play an essential role.

6.3 Storage of progression

In the Hilbert space storage can be represented by an integer or rational eigenvalue of a self adjoint operator. In a paginated model this would mean that this operator has only one eigenvalue. However, the sequence of Hilbert spaces can be joined such that a range of subsequent rational numbers act as eigenvalues of the self adjoint operator. A covering normal operator can act as reference operator, which is used to deliver the discussed flat parameter space. This would deliver a model with a single infinite dimensional separable Hilbert space and a Gelfand triple that fits to this Hilbert space via the corresponding reference operators.

The Hilbert Book Model prefers to stay with the paginated space progression view, which uses an ordered sequence of Hilbert spaces that each represent a static status quo of the discrete objects that exist in the whole model. In the corresponding reference eigenspaces the real parts of the eigenvalues are all equal and represent the current progression value.

However, it is smart to keep a single Gelfand triple that fits to all these separate Hilbert spaces. In this way progression flows in the Gelfand triple and the operating system can use this fact in order to establish dynamic coherence.

6.4 Spacetime model

At this stage the model deviates significantly from the spacetime model that is used in contemporary physics. The spacetime model features a Minkowski signature, while the paginated model features a Euclidean signature.

The difference between the spacetime model and the paginated space-progression model is located in the role of the observer. In the spacetime model the observer plays an essential role.

The progression parameter of the paginated space progression model has much in common with the proper time concept in the space time model. Proper time is ticking on a virtual clock that ticks at the location of the observed item. In the paginated space-progression model all proper time clocks are synchronized. In the spacetime model proper time may be estimated from the readings of a suitable clock that is located at the position of the observer.

The spacetime model offers another notion of time. This is the coordinate time. Usually coordinate time is measured using a clock at the location of the observer. This makes coordinate time an easily observable value. The virtual proper time at the location of the observed item is deduced from this measurement and the knowledge about the information path that runs from the observed item to the observer. The value includes the clock ticks that pass during the travel of the information from the observed item until it reaches the observer. That travel is supposed to occur with the highest possible speed. Thus, coordinate time is a mixed concept. It includes the information path that runs from observed item to the observer. In arbitrary curved space this path is not exactly known.

Since the coordinate time can also be interpreted as the proper time of the observer, the notion of coordinate time can bring much confusion. The HBM avoids this confusion by using progression as a well-defined parameter.

6.5 The Hilbert Book Model

Due to the great resemblance of the members of the sequence with the pages of a book and its relation with Hilbert spaces, the model is baptized "***The Hilbert Book Model***".

6.6 The operating system

A very opaque part in the planned model is the external operating system that does its job out of sight, but is very powerful because it controls the whole lot. It could perform any trick, but that is not the case. It must do its job by using the parts of the model that keep in sight. The OS uses the eigenspaces of operators in the Hilbert space and in the Gelfand triple as storage media. These parts contain observable data. The OS selects a special kind of normal operator that provides eigenvalues that act as the locations that will be managed by the OS. These locations and the corresponding eigenvectors form special sets. This results in a special category[8] of building blocks. These eigenvectors span the subspaces on which the OS operates.

The OS can use Fourier transforms, because both the Hilbert space and the Gelfand triple supports them. The OS can apply the superposition principle that resides in the Hilbert space as a binding tool.

Its main task is providing spatial and dynamic coherence. The way how Hilbert spaces and Gelfand triples are linked offers choices. It is possible to give every Hilbert space its own Gelfand triple. This does make the job of the OS quite complicated. Another choice is to let

[8] The F-category

a single Gelfand triple serve a complete ordered sequence of Hilbert spaces. In this way the OS can use a series of eigenspaces of the Gelfand triple in order to follow the changes in the members of the sequence of Hilbert spaces as a function of a flowing progression. One of the eigenspaces can act as parameter space and other eigenspaces can contain target values of quaternionic functions. This choice makes the work of the OS a lot more straightforward. However, all these Hilbert spaces must fit properly on this single Gelfand triple and that is only possible when it is partly done in an inaccurate way.

This inaccurate fit introduces the stochastic features of the model.

The eigenspaces of subsequent members of the sequence of Hilbert spaces will slightly differ in a stochastic way! With other words the embedding of discrete objects that are taken from the Hilbert spaces into continuums that are taken from the Gelfand triple occurs in a stochastic way.
The locations at which the embedding occurs will form a coherent swarm. The OS controls this coherence.

6.6.1 Gelfand triple fit

Due to the fact that neither the Hilbert space nor the Gelfand triple provides a means to implement dynamic

control, the HBM has decided to use a sequence of slightly different Hilbert spaces that link to a single Gelfand triple.

The sequence of Hilbert spaces can be represented by a single integral Hilbert space. In that way a model is generated that is implemented by a single Hilbert space and a single Gelfand triple that can DESCRIBE dynamics. This model cannot control the coherence of dynamics. This model steps with model wide progression steps. It requires an external mechanism that for each of these steps ensures dynamic coherence.

The linking element between the single integral Hilbert space and the Gelfand triple is a reference normal operator that occurs in this integral Hilbert space and that has the full set of rational quaternions as its eigenvalues. This reference operator links ***precisely*** to a corresponding reference normal operator in the Gelfand triple that has the full set of real quaternions as its eigenvalues. This means that in the model apart from the representatives of progression the reference operators form static ingredients.

Let us now go back to the sequence of Hilbert spaces, which gives a cleaner view of what is happening.

Since the elements of the sequence of Hilbert spaces differ, the mutual difference must be located in the eigenspaces of other Hilbert space operators. Their eigenspaces correspond to progressed versions of the eigenspaces of operators that reside in the Gelfand triple. With other words these Gelfand triple operators and their eigenspaces are continuous functions of progression.

This can be interpreted as follows. The reference operator's eigenspace can be used as parameter space of a quaternionic function that maps the parameter space onto a target space. This holds for the Hilbert space as well as for the Gelfand triple. Like what happened to the reference eigenspaces, the target space that resides in the Hilbert space is embedded in the target space that resides in the Gelfand triple. However, this time the embedding ***occurs in an imprecise way***. The difference is established in a stochastic way. ***Any preprogrammed way would be traceable***. Still sufficient coherence must be ensured. That means that every embedded discrete object must obey statistically defined restrictions. The result is that the subsequent embedding locations form a coherent swarm that is characterized by a continuous density distribution.

6.6.2 Superposition management

Another important task of the operating system is the management of what free composites and building blocks are. This means that it controls the temporal evolution of superposition coefficients and of Hilbert space subspaces. Via the existence of Fourier transforms this means that the OS controls oscillations of constituents that are internal to composites.

A very striking capability of the operating system is the fact that it can decide which objects can take part in superpositions. A well-known phenomenon is the ***Pauli principle***, which says that only fermions with different properties can take part in the superpositions that determine a free composite. This is easily comprehended if the elementary fermions are represented by eigenvectors that span the subspace which represents the composite.

Via superposition management, the OS controls the process that binds building blocks and lower order composites into higher order composites and it controls phenomena, such as non-locality.

7 The embedding process

7.1 Embedding a building block

The members of the sequence of Hilbert spaces can be considered to be recreated at every progression step. Thus the embedding of a building block is a recurrent operation. Since the subsequent elements of the sequence must not differ much, the embedding will differ not much of the same embedding in the previous member. For example the location of the embedding must be nearly the same. After a series of progression steps, the locations used by the embedding of the considered building block form a swarm. This swarm forms a coherent set of used locations.

The mechanism that takes care of the dynamic coherence uses the density distribution of the swarm in order to regulate this coherence. This means that this density distribution is a continuous function. Since the locations are points in a continuum the normalized version of the location density distribution can also be characterized as a probability density distribution. That probability density distribution is a continuous function that defines the probability of finding the building block at the location that is given by the value of the parameter of the building block.

7.2 Swarming conditions

It is suggested here that the mechanism, which installs dynamic coherence installs a series of swarming conditions.

1. The swarm is prepared out of sight in advance of its usage and in complete seclusion.
2. This preparation occurs in a flat working space.
3. The locations that are used by the embedding of a single building block form a coherent set.
4. The swarm is characterized by a set of discrete symmetries.
5. The set is characterized by a continuous location density function.
6. This density function is characterized by the same symmetry flavor.
7. The normalized version of the density distribution can also be interpreted as a probability density distribution
8. The probability density distribution has a Fourier transform

The reason for this suggestion is the great resemblance of the probability density distribution of the building block with the squared modulus of the wave function of elementary particles.

The last swarming condition has some strong consequences.

1. The fact that the swarm has a Fourier transform means that it owns a displacement generator.
2. The fact that the swarm owns a displacement generator means that at first approximation the swarm moves as one unit
3. The fact that the probability density distribution has a Fourier transform means that it can be interpreted as a wave package
4. As a consequence interfering swarms can form detection patterns in the form of interference patterns.

We already added the following conditions:

1. The swarm is prepared in advance
2. This preparation occurs in seclusion

3. It means that the preparation procedure can select its own set of discrete symmetries.

We can further add the following suggestions:

1. The planned swarm contains a characteristic number of potential locations. This suggests a characteristic recycle period.
2. After preparation the planned swarm is mapped onto the actual (eventually curved) continuum.
3. That target continuum has its own symmetry flavor, which may differ from the symmetry flavor that is used for the preparation of the swarm.
4. At each progression step, after the mapping onto the target continuum, via random choice, a single location is selected as the currently active location.
5. Each location in the planned swarm is used only once.
6. After using all locations a new planned swarm is generated.

7. The regeneration cycle and the consumption cycle must synchronize.
8. The planned swarm characterizes the type of the building block

7.3 Micro-path

The hopping of the building block along the locations that are selected from the swarm can be interpreted as the hopping along a stochastic micro-path.
This hopping also occurs when the swarm as a whole stays at the same location.
If the swarm moves, then the micro-path stretches along the movement path of the swarm.
If the swarm oscillates with small enough amplitudes, then the oscillation will be drowned in the micro-path.
The micro-path may implement a quasi-rotation.
The micro-path may be walked in one of two directions.

We add the following observations:

1. Like the swarm the micro-path contains a characteristic number of hops.
2. The micro-path need not be a closed loop.
3. At each full cycle the swarm as a whole may have taken a swarm movement step.
4. Non-moving swarms may appear to jitter.

7.4 Building block diversity

This list already indicates that several types of swarms may exist. These types differ in their basic characteristics. These basic characteristics are:

- Open path versus closed path
- Number of involved locations
- Discrete symmetry set of location distribution
- Discrete symmetry set of embedding continuum

This diversity means a large diversity of potential building blocks. All these types must be served by a dedicated subtask of the OS. These tasks must run in parallel. If these types can superpose then these subtasks must synchronize and must finish within a fixed number of basic progression steps. This is satisfied when all subtasks take the same cycle period. Also the production of the subtask must be consumed in that cycle period. If the full cycle period is used, then the delivered locations are consumed such that a variable number of delivered locations corresponds with a variable temporal pace.

7.5 Blurred view toolkit

Two of the swarming conditions are introducing another less detailed view on the corresponding construction element.
The first of these two is: The swarm must be so coherent that it can be described by a continuous density distribution.
The second is: The swarm must be so coherent that the normalized version of this continuous density distribution has a Fourier transform.

These conditions are implemented by the mechanism, which is responsible for ensuring sufficient dynamic coherence between subsequent progression steps. The swarm is stored eigenspaces that reside in the Hilbert space The continuous density distribution can be stored in an eigenspace of a suitable operator that resides in the Gelfand triple.

The change to another view is the change to a blurred view. The fine stochastic geometric details that are present in the eigenspaces of Hilbert space operators are smoothed such that their spatial and temporal effects are effectively averaged.

Contemporary physics appears to restrict to this blurred view. With this toolkit, even a return to the Hilbert

space starts from the normalized continuous density distributions or their Fourier transform. The density operator and the density matrix are examples of this approach.

The blurred view opens the possibility to use the full toolkit that is offered by Lie groups and Lie algebras. That is how the equations of contemporary physics are formatted.
Hardly anybody sees that they are representations of a fundamentally blurred view that effectively hides most of the stochastic occurrences.

This view is cultivated and ensured by the fact that most physicist require experimental verification of any significant physical statement.
The stochastic occurrences are not directly observable and only their averaged effects become observable. However, that does not mean that they do not exist. if they exist, then it is possible to reason about them and analyze what the possibilities are. This is what the HBM distinguishes from contemporary physics.

8 The mapping process

The embedding of a building block can be considered as a mapping process. First the operating system prepares a planned swarm in a flat continuum. Next this planned swarm is mapped onto the target continuum, which is curved. At each progression step one location is selected via a random choice out of the mapped swarm. At this location the building block resides during this progression step.

Here we describe a potential preparation and mapping procedure. The preparation of the planned swarm can be considered as a stochastic process, that consists of two separate stochastic processes. The first process is a Poisson process that produces a germ. The second process is a binomial process that is implemented by a 3D spread function whose parameter is formed by the germ. We will call the combination of the two stochastic processes a ***stochastic spatial spread function***.
The result of the stochastic spatial spread function is mapped onto the target continuum. This map can be implemented by a ***continuous quaternionic allocation function*** that has a flat parameter space that is spanned by a quaternionic number system.
This quaternionic function defines the target embedding continuum.

The total map can be considered as the convolution of the stochastic spatial spread function and the continuous quaternionic allocation function.

8.1 Oscillation

The above description is a greatly simplified representation. For example the generation of the planned swarm may involve a harmonic oscillation. In that case the elements of the swarm may reflect the consequences of the oscillation, but the swarm will not oscillate. The cycle period of the oscillation must fit onto the cycle period of the generation of the swarm.

8.2 Mapping quality

The Fourier transform of the location density distribution that describes the planned swarm acts as a quality characteristic of the mapping process that is installed by the mechanism that controls the dynamic coherence.
This quality characteristic works together with the Optical Transfer Function that acts as quality characteristic of linear imaging equipment.
The mapping quality characteristic corresponds to the frequency characteristic that characterizes the quality of signals that are transferred by linear operating communication equipment

8.3 The imaging process

If particles move then at every instance of progression the product of the mapping quality characteristic and the Optical Transfer Function that is defined by the configuration of apertures[9] and potentials that together constitute the boundary conditions, produces the effective probability of the potential detection pattern of the considered particle.

[9] Apertures can be considered as potential walls.

9 Quaternions and quaternionic functions

9.1 Number systems

The numbers that can be used as coefficients in superpositions and as eigenvalues of linear operators in separable Hilbert spaces and their Gelfand triple must be elements of a suitable division ring. Only three suitable division rings exist:

- The real numbers
- The complex numbers
- The quaternions

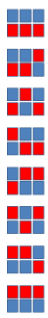
The complex numbers comprise the real numbers and the quaternions comprise the complex numbers. Thus the quaternions form the most elaborate choice.
An N-dimensional number system exist in 2^N versions that only differ in their discrete symmetries. This means that the quaternionic number system exist in 16 symmetry flavors.

9.2 Quaternions

9.2.1 Quaternion symmetry flavors

Quaternionic number systems exist in 16 versions that differ in their symmetry flavor

- If the real part is ignored, then still ***8*** symmetry flavors result
- They are marked by special indices $\boldsymbol{a}^{④}$
- $\boldsymbol{a}^{⓪}$is the reference symmetry flavor
- They are also marked by colors $N, R,\ G, B, \bar{B}, \bar{G}, \bar{R}, \bar{N}$
- Half of them is right handed **R,**
- The other half is left handed **L**

 $\boldsymbol{a}^{⓪} N\ \boldsymbol{R}$ $\boldsymbol{a}^{①} R\ \boldsymbol{L}$ $\boldsymbol{a}^{②} G\ \boldsymbol{L}$ $\boldsymbol{a}^{③} B\ \boldsymbol{L}$ $\boldsymbol{a}^{④} \bar{B}\ \boldsymbol{R}$ $\boldsymbol{a}^{⑤} \bar{G}\ \boldsymbol{R}$ $\boldsymbol{a}^{⑥} \bar{R}\ \boldsymbol{R}$ $\boldsymbol{a}^{⑦} W\ \boldsymbol{L}$	The colors reflect the directions of the axes.

The fact that these symmetry flavors exist becomes apparent when several sets of quaternions are prepared in private seclusion via a procedure that works according to a selected set of discrete symmetries. If these sets correspond to different symmetry flavors, then this results in different results when the geometry of the sets are compared or if their elements are used in mixed arithmetic computations.

The symmetry flavor is not stored in the individual quaternions. The symmetry flavor characterizes the full set!

Comparing geometry or performing arithmetic breaks the restrictions of an existing seclusion.

9.2.2 Quaternion geometry and arithmetic

Quaternions can be considered as the combination of a real scalar and a 3D vector that has real coefficients. This vector forms the imaginary part of the quaternion. Quaternionic number systems are division rings. Bi-quaternions exist whose parts exist of a complex scalar and a 3D vector that has complex coefficients. Bi-quaternions do not form division rings. The HBM does not use them.

9.2.2.1 Notation

We indicate the real part of quaternion a by the suffix a_0.
We indicate the imaginary part of quaternion a by bold face $\boldsymbol{a}$.

$$a = a_0 + \boldsymbol{a} \tag{1}$$

9.2.2.2 Sum

$$c = c_0 + \boldsymbol{c} = a + b \tag{1}$$

$$c_0 = a_0 + b_0 \tag{2}$$

$$\boldsymbol{c} = \boldsymbol{a} + \boldsymbol{b} \tag{3}$$

9.2.2.3 Product

$$f = f_0 + \boldsymbol{f} = d\ e \tag{1}$$

$$f_0 = d_0 e_0 - \langle \boldsymbol{d}, \boldsymbol{e} \rangle \tag{2}$$

$$\boldsymbol{f} = d_0 \boldsymbol{e} + e_0 \boldsymbol{d} + \boldsymbol{d} \times \boldsymbol{e} \tag{3}$$

9.2.2.4 Norm

$$|a| = \sqrt{a_0 a_0 + \langle \boldsymbol{a}, \boldsymbol{a} \rangle} \tag{1}$$

9.2.2.5 Rotation

Quaternions are often used to represent rotations.

$$c = ab/a \tag{1}$$

rotates the imaginary part of b that is perpendicular to the imaginary part of a.

9.3 Discrete quaternionic distributions

A distribution of quaternionic geometric location and displacement data can be stored in a discrete quaternionic distribution.
The locations are stored in the real part of the discrete quaternionic distribution as binary valued functions of a rational quaternionic parameter space and the displacements are stored in the imaginary part of the discrete quaternionic distribution. If the locations form a connected path, then both the quaternionic distribution and the path characterize the situation. This situation occurs in the embedding process.

Swarms are candidates for such descriptors. The locations and the corresponding hops form the elements of the discrete quaternionic distribution and progression acts as an enumerator of these elements.
Together with this enumerator, the discrete quaternionic distribution defines a path.

If the discrete data belong to the same symmetry flavor and the density of these discrete data forms a sufficiently smooth function, then the discrete distribution can be described by a continuous quaternionic density distribution. This continuous quaternionic density distribution no longer describes the separate locations and it

no longer describes the path. Thus, this step to a continuous description involves significant loss of information.

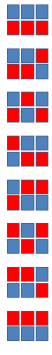
Due to the fact that the locations are points, the real part of a normalized version of this continuous density distribution can be considered as a probability density distribution.

9.4 Quaternionic functions

9.4.1 Quaternionic function symmetry flavors

Continuous quaternionic functions do not switch to other symmetry flavors.

- If the real part is ignored, then still ***8*** symmetry flavors result
- They are marked by special indices $\boldsymbol{\psi}^{④}$
- $\boldsymbol{\psi}^{⓪}$ is the reference symmetry flavor
- They are also marked by colors $N, R,\ G, B, \bar{B}, \bar{G}, \bar{R}, \bar{N}$
- Half of them is right handed **R,**
- The other half is left handed **L**



$\boldsymbol{\psi}^{⓪}_{N\ \boldsymbol{R}}$
$\boldsymbol{\psi}^{①}_{R\ \boldsymbol{L}}$
$\boldsymbol{\psi}^{②}_{G\ \boldsymbol{L}}$
$\boldsymbol{\psi}^{③}_{B\ \boldsymbol{L}}$
$\boldsymbol{\psi}^{④}_{\bar{B}\ \boldsymbol{R}}$
$\boldsymbol{\psi}^{⑤}_{\bar{G}\ \boldsymbol{R}}$
$\boldsymbol{\psi}^{⑥}_{\bar{R}\ \boldsymbol{R}}$
$\boldsymbol{\psi}^{⑦}_{W\ \boldsymbol{L}}$

The colors reflect the directions of the axes

Thus continuous quaternionic functions also exist in 16 versions that only differ in their symmetry flavor.

The fact that these symmetry flavors exist becomes apparent when several continuous quaternionic functions are prepared via a single procedure that works according to a selected set of discrete symmetries. If these functions correspond to different symmetry flavors, then this results in a different result when the geometry of the functions is compared or if their values are used in mixed arithmetic computations.

The symmetry flavor can also be attached to quaternionic functions that are mostly continuous. They must be continuous apart from a countable set of local singularities.

9.4.1.1 Symmetry flavor bundle

Mostly continuous functions are functions that are continuous apart from a finite number of ***singular points.***
Mostly continuous quaternionic functions exist in **16** different ***symmetry flavors.***
Mostly continuous quaternionic functions exist in ***bundles*** that contains all symmetry flavors of that function.
These functions share the same parameter space and that parameter space is spanned by a quaternionic number system.
Such bundles are called ***symmetry flavor bundles***.

A symmetry flavor bundle has one reference element. It is the element that has the same symmetry flavor as the parameter space has.

9.4.1.2 Palestra

The HBM uses a selected symmetry flavor bundle in order to represent its embedding continuum. That bundle is called ***Palestra***.

One of the elements of this bundle is the reference element and owns the symmetry flavor that is residing in the parameter space. If a single embedding continuum with no further indication is mentioned, then this reference member of the Palestra is meant.

9.4.2 Algebra

We use similar notations as for quaternionic numbers. Without further notice, we suppose that the parameter space is formed by a selected quaternionic number system.

9.4.3 Notation

$$g(q) = g_0(q) + \boldsymbol{g}(q) \tag{1}$$

g is a quaternionic function.
g_0 is a real scalar function.
$\boldsymbol{g}$ is a real vector function. It is the imaginary part of g.
q is a quaternion that resides in the parameter space.

$$q = \{\tau, x, y, z\} = \{q_0, q_1, q_2, q_3\} \tag{2}$$

$$= q_0 + \boldsymbol{q} = q_0 + q_1\boldsymbol{I} + q_2\boldsymbol{J} + q_3\boldsymbol{K}$$

9.4.4 Sum

g can be a quaternion or a function $g(q)$.
h can be a quaternion or a function $h(q)$.

$$k = k_0 + \boldsymbol{k} = g + h \tag{1}$$

$$k_0 = g_0 + h_0 \tag{2}$$

$$\boldsymbol{k} = \boldsymbol{g} + \boldsymbol{h} \tag{3}$$

9.4.5 Product

d can be a quaternion or a function $d(q)$.
e can be a quaternion or a function $e(q)$.

$$f = f_0 + \boldsymbol{f} = d\ e \tag{1}$$

$$f_0 = d_0 e_0 - \langle \boldsymbol{d}, \boldsymbol{e} \rangle \tag{2}$$

$$\boldsymbol{f} = d_0 \boldsymbol{e} + e_0 \boldsymbol{d} + \boldsymbol{d} \times \boldsymbol{e} \tag{3}$$

9.4.6 Differentiation

If g is differentiable then the quaternionic nabla ∇g of g exists.
The quaternionic nabla ∇ is a shorthand for $\nabla_0 + \boldsymbol{\nabla}$

$$\nabla_0 = \frac{\partial}{\partial \tau} \tag{3}$$

$$\boldsymbol{\nabla} = \left\{ \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right\} \tag{4}$$

$$h = h_0 + \boldsymbol{h} = \nabla g \tag{4}$$

$$h_0 = \nabla_0 g_0 - \langle \boldsymbol{\nabla}, \boldsymbol{g} \rangle \tag{5}$$

$$\boldsymbol{h} = \nabla_0 \boldsymbol{g} + \boldsymbol{\nabla} g_0 + \boldsymbol{\nabla} \times \boldsymbol{g} \tag{6}$$

9.4.7 Norm

Square-integrable functions are normalizable. The norm is defined by:

$$\|\psi\| = \int_V |\psi|^2 \, dV \tag{1}$$
$$= \int_V \{|\psi_0|^2 + |\boldsymbol{\psi}|^2\} dV$$
$$= \|\psi_0\| + \|\boldsymbol{\psi}\|$$

9.4.8 The coupling equation

The coupling equation follows from peculiar properties of the differential equation. We start with two normalized functions ψ and φ.

$$\|\psi\| = \|\varphi\| = 1 \tag{1}$$

These normalized functions are related by:

$$\Phi = \nabla\psi = m\,\varphi \tag{2}$$

$\Phi = \nabla\psi$ defines the differential equation. (3)

$\nabla\psi = \Phi$ formulates a continuity equation. (4)

$\nabla\psi = m\,\varphi$ formulates the coupling equation. It couples ψ to φ, where φ is located in the embedding continuum and acts as source.

m is the coupling factor.

9.4.8.1 In Fourier space

The Fourier transform of the coupling equation is:

$$\mathcal{M}\tilde{\psi} = m\tilde{\varphi} \tag{1}$$

$\mathcal{M}$ is the ***displacement generator***

9.4.8.2 The Dirac equation

The Dirac equation runs:

$$\nabla_0[\psi] + \boldsymbol{\nabla}\boldsymbol{\alpha}[\psi] = m\beta[\psi] \tag{1}$$

$[\psi]$ is a Spinor.

$\boldsymbol{\alpha}$ and β are ***Dirac matrices***

Dirac matrices	**Pauli matrices**
$\alpha_1 \equiv \begin{bmatrix} 0 & \boldsymbol{i} \\ -\boldsymbol{i} & 0 \end{bmatrix}$	$\boldsymbol{i} \longmapsto \sigma_1 \equiv \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
$\alpha_2 \equiv \begin{bmatrix} 0 & \boldsymbol{j} \\ -\boldsymbol{j} & 0 \end{bmatrix}$	$\boldsymbol{j} \longmapsto \sigma_2 \equiv \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$
$\alpha_3 \equiv \begin{bmatrix} 0 & \boldsymbol{k} \\ -\boldsymbol{k} & 0 \end{bmatrix}$	$\boldsymbol{k} \longmapsto \sigma_3 \equiv \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$
$\beta \equiv \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$	$1 \longmapsto I \equiv \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

The 2x2 matrices combine into 4x4 matrices.

Split into right handed and left handed spinors the Dirac equation looks:

$$\nabla_0 \psi_R + \boldsymbol{\nabla} \psi_R = m \psi_L \quad (2)$$

$$\nabla_0 \psi_L - \boldsymbol{\nabla} \psi_L = m \psi_R \quad (3)$$

9.4.8.3 Dirac equation in quaternionic format

$\nabla \psi = m \psi^*$ holds for the electron. (1)

$\nabla^* \psi^* = m \psi$ holds for the positron. (2)

ψ^* is the quaternionic conjugate from ψ.

Thus the electron and the positron couple to another member of the same symmetry flavor bundle to which the quantum state function belongs.

The positron does obey the conjugate of the coupling equation. It looks as if no difference exists between the two equations. However, the parameters of the functions are not touched by the conjugation.

$\nabla \psi = m \psi^*$ is a special form of the coupling equation. Here the source function φ equals ψ^*. The quantum state function ψ acts as a drain.

10 Space hypothesis

10.1 The Palestra

The Palestra is the name of a symmetry flavor bundle that pays the role of our living space.

This selection is raised by the fact that the Dirac equation seems to couple two members of a symmetry flavor bundle. Accepting the elementary coupling equation as a valid equivalent of the Dirac equation for other elementary particle offers the opportunity to suggest the existence of a large variety of these particles.

The elementary coupling equation can be interpreted as the description of the embedding of a free elementary particle in a member of the Palestra.

The scope of the Palestra is the whole Hilbert space. The scope of the coupling equation is the subspace that represents the corresponding building block or composite.

10.2 The space hypothesis

Now we can formulate the space hypothesis.

> Our living space can be represented by a field that is represented by a ***symmetry flavor bundle.*** That field is called ***Palestra.***

Everything in universe consists of features of the Palestra

10.3 The embedding of elementary particles

All artifacts in universe are free elementary particles or they are composites of elementary particles. The constituents of the composites are bounded in a modular way. The elementary particles represent locations where members of the symmetry flavor bundle couple. At those locations the elementary particles can be considered to be embedded in one of the two coupling members of the Palestra.
The locations of this embedding form a swarm. This swarm characterizes the embedded particle.
The continuous density distribution that describes the swarm conforms to the squared modulus of what we know in contemporary physics as the wave function of the elementary particle. The restriction to the continuous description neglects much of the geometric and dynamic details. It delivers a ***blurred view*** of what exists and what occurs.

11 Preparing the swarm

11.1 Location of dynamic coherence control

Contemporary physics locates the dynamic control in one of two places. The Schrödinger picture locates the dynamics in the quantum state functions. The Heisenberg picture locates dynamic control on the operators and their eigenspaces. In both cases it is not clear how that control is organized. The equations only indicate how these actuators apply their effects.
In contrast the Hilbert Book Model locates the control of dynamic coherence in the operating system that is external to the Hilbert spaces and to the Gelfand triple. This location is out of reach of direct observations. Only the results of the actions of the operating systems may become noticeable. This may become apparent via the actions of the OS and via the rules that the OS appears to oppress. Another more direct way is via the storage places of the model. The eigenspaces of operators in the Hilbert space act as storage places for observable values. As is indicated above the view via the representation in the continuum eigenspaces that reside in the Gelfand triple tends to blur the geometric and dynamic details.

11.2 Storage

The HBM suggests that the whole swarm is prepared in advance of its usage. This preparation occurs in seclusion. The prepared swarm is stored in a persistent location. That must be an eigenspace of an appropriate operator that resides in the Gelfand triple. We will call this operator the planned-swarm operator. The prepared swarm consists of a coherent set of locations and displacements that are generated relative to the eigenspace of an operator that provides a flat parameter space that is formed by a selected quaternionic number system[10].

11.3 Suggested creation mechanism

The set of locations is created by a combination of a Poisson process that delivers a stochastic sequence of (real) rational numbers that act as design parameters. The Poisson process is combined with a binomial process that uses the design parameters as parameter of a 3D spread function. Together these processes produce a stochastic spatial spread function whose results can be stored in a discrete quaternionic distribution. On its turn this discrete quaternionic distribution is stored in (mapped onto) the eigenspace of the planned-swarm operator in the Gelfand triple.

---

[10] A quaternionic number system with a selected symmetry flavor.

As indicated earlier the discrete quaternionic distribution implements a path of subsequent locations.

11.3.1 Swarm usage

The usage of the swarm can be interpreted in two ways:

- The process works in cycles and the integral result of the cycle is used together with a random selection procedure.
- The process delivers its results immediately (It already represents a random selection).

The HBM prefers the first interpretation. In that case it is possible to map the swarm to its target continuum and after that the random selection can occur.

11.3.2 Example distribution

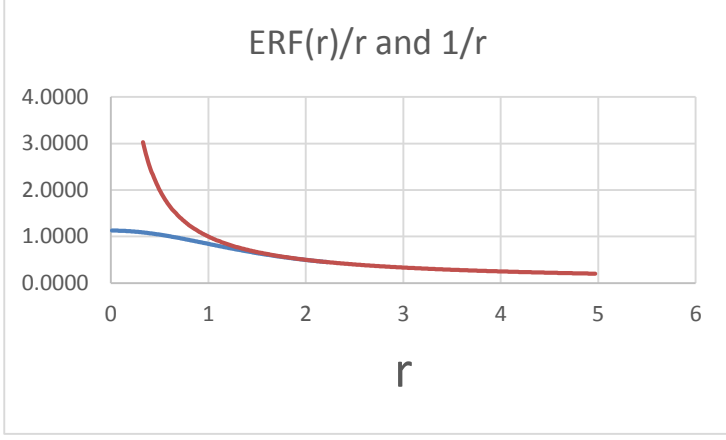
As an example the combination of the Poisson process and the binomial process may generate a discrete quaternionic distribution that comes close to a 3D Gaussian distribution[11].

A charge distribution in the form of this example distribution corresponds to an isotropic potential in the form

[11] A 3D normal distribution.

$$\frac{Erf(r)}{r} \tag{1}$$

This quickly reduces to the $1/\boldsymbol{r}$ form of the gravitational potential of a single charge. In contrast to the single charge potential, the potential of the charge distribution does not contain a singularity.
The $1/r$ format is due to the form of the Green's function of the single charge potential. The reason of existence of this potential will be given later in the chapter that treats the embedding process.



Due to the swarm, the potential of the particle has no longer a singularity.

The swarm may contain the effects of harmonic spherical oscillations. This example does not contain harmonic oscillations. However, together with a random selection function it generates a micro-path.

11.4 The stochastic spatial spread function

The generator of the planned swarm will be called stochastic spatial spread function and it will be indicated with symbol $\mathcal{S}$.

The generated swarm can be represented by a continuous quaternionic density distribution, which is also a quaternionic probability density distribution. This quaternionic function is indicated with symbol ψ. This representation neglects the detailed geometric and dynamic location information!

11.5 Adding oscillations

The swarm is prepared in the realm of the operating system. This preparation is non-observable. Only the results become observable after mapping them onto the embedding continuum.

The preparation takes its own cycle time. That cycle runs synchronous with the progression steps, but at a significantly lower frequency. The preparation may include extra features, such as harmonic oscillations that happen internal to the planned swarm. These internal oscillations can be considered as extra constituents. Thus a

swarm that includes oscillations can be considered as a composite.

12 Interpreting the coupling equation.

In this chapter we use our knowledge of what we know of physical reality in order to make our model design decisions.

12.1 Uniform movement

When a swarm moves uniformly in a rather flat embedding continuum, then due to the symmetry of the embedding continuum two viewpoints are possible. One viewpoint moves with the swarm and does not “see” the influence of the movement. The other viewpoint does not move and “sees” the swarm unfolding along the movement path. That means that according to this second viewpoint a closed micro-path is enforced to open and stretch along the movement path. When the condition is reached, in which the micro-path is completely parallel to a geodesic, then the maximum speed of movement is reached.
A free open path particle already reached that condition. It can be considered to go as fast as the fastest closed path particle.

12.2 Speed

The definition of the norm involves an integral.
For a continuous location density distribution this means:

$$\|\psi\| = \int_V |\psi|^2 \, dV$$

The coupling equation in integral format runs:

$$\|\phi\| = \int_V |\phi|^2 \, dV = \int_V |\nabla\psi|^2 \, dV$$

$$= m^2 \int_V |\psi|^2 \, dV = m^2$$

In this part of the analysis we suppose that only stochastic and no structural differences exists between hop sizes.

Now let us apply this to the swarm by replacing the integral by a summation of squared hop sizes $|h_i|$.

$$m^2 = \sum_i^N |h_i|^2 = N\overline{|h_\iota|^2}$$

h_i is the quaternionic value of the *i*-th hop. It is an imaginary quaternion. N is the number of elements in the swarm[12]. N is not affected by uniform movement.

$$h_i = l_i - l_{i-1}; i = 1 \dots N$$

l_0 is the start location. l_i is the location of the *i*-th swarm element.

The displacement of the whole swarm after a full cycle is:

$$\Delta_{\boldsymbol{s}} = \sum_{i}^{N} \boldsymbol{h_i}$$

$\Delta_{\boldsymbol{s}}$ is a vector. This move takes N progression steps. Thus the swarm speed is

$$\boldsymbol{v} = \frac{\Delta_{\boldsymbol{s}}}{N\,\Delta_{\tau}}$$

[12] Later we will see that this interpretation only holds for closed micro-paths. N depends on the type of the closed path particle.

$N\ \Delta_\tau$ is the swarm recycle period. It is the duration of walking through the full micro-path. $\boldsymbol{v}$ is a vector. Δ_τ is the progression step size.

12.3 Maximum speed

The HBM assumes that for a selected particle type the average hop size is a constant. In that case the swarms maximum speed is reached when all hops are parallel to a part of a geodesic.

$$m^2 = \sum_j p_j \left\{ \sum_i^{N_j} |h_{ij}|^2 \right\} = \sum_j p_j N_j \overline{|h_{ij}|^2}$$

p_j is the probability of type j in the composite.

The micro-path wraps along the movement path of the swarm. In the most extreme case the path fits on a part of a single geodesic. The whole swarm is stretched along the geodesic. All hops are part of the geodesic. It means that a closed path particle looks as if it is un-folded in a completely stretched open path particle. The next cycle starts at the end of the previous cycle.
Now suppose that in each particle type the average hop size stays the same, then the distance covered by N hops is

$$\Delta_{smax} = \sum_{i}^{N_{type}} |h_i| = \overline{|h_\iota|}_{type}\, N_{type}$$

Δ_{smax} is a real number.
Here for the selected particle type $\overline{|h_\iota|}_{type}$ is the average value of the hop size $|h_i|$.
This holds for open as well as closed paths. For the particle speed holds:

$$c = \frac{\Delta_{smax}}{N_{type}\, n_{type}\, \Delta_\tau}$$

$$= \frac{N_{type}\overline{|h_\iota|}_{type}}{N_{type}\, n_{type}\, \Delta_\tau}$$

$$= \frac{\overline{|h_\iota|}_{type}}{\Delta_\tau\, n_{type}}$$

$$\overline{|h_\iota|}_{type} = n_{type}\, c\ \Delta_\tau$$

c is at least a ***constant*** for all constituents of a moving composite. Otherwise the composite is torn apart.

Each type has its own ***number*** N_{type} of hops.

Δ_τ is the progression step size. It is a model constant. The ***hop duration*** $n_{type}\ \Delta_\tau$ is particle type dependent. $N_{type}\ n_{type}\ \Delta_\tau$ is the ***particle generation & consummation duration***.

Three categories of particles exist

- Closed path particles with a fixed number N_{std} of particles. This category contains only one type[13].
- A special category of closed path particles relate to harmonic oscillations.
- Open path particles

The category of harmonic particle types has no standard number of hops and superposes with closed path particles with fixed number N_{std} of hops.

An open path particle type may contain N_{std} or less hops.

[13] We do not yet consider symmetry dependencies.

The HBM suggests that open path particle types correspond to a harmonic closed path particle types that features the same number of hops. These particles may convert in each other.

The conversion of fixed closed path particles into open path particles is also possible, but that is much more complicated.
A transition from a fixed number closed path particle in an open path particle starts with the merger of such a particle with an anti-particle that results in a temporary combined particle, which then splits into two open path particles. This procedure ***annihilates*** the merged fixed number closed path particle ***pair***. If in this procedure the number of hops is preserved, then the emitted open path particle has the same number of hops as the fixed number closed path particle had.

The converse transition combines two open path particles into a temporary closed path particle, which then splits into two fixed number closed path particles, which are each other's anti-particle. This procedure is known ***as pair production***.

The existence of a generally valid maximum speed of building blocks is the base of ***special relativity theory***.

In contemporary physics c is considered to be equivalent to the ***speed of free information transfer***.

12.3.1 Closed path particles

For fixed number closed path particles hold:

$$m^2 = \sum_i^N |h_i|^2 = N\overline{|h_\iota|^2}$$

$$\sigma_{|h_i|} = \sqrt{\sum_i^N \left(|h_i| - \overline{|h_\iota|}\right)^2}$$

$\sigma_{|h_i|}$ is the standard deviation of the step size $|h_i|$.

$$\sigma_{|h_i|}^2 = var(|h_i|) = \sum_i^N \left\{|h_i|^2 - \left(\overline{|h_\iota|}\right)^2\right\}$$

$$= N\overline{|h_\iota|^2} - N\left(\overline{|h_\iota|}\right)^2$$

$$= m^2 - N\,(c\,\Delta_\tau)^2$$

$$= m^2 - \frac{\Delta_S^2}{N}$$

$$m^2 = \sigma_{|h_i|}^2 + \frac{\Delta_s^2}{N}$$

N, c, Δ_τ and$\Delta_s$are supposed to be constants. Thus m depends on $\sigma_{|h_i|}$. For particles at rest this is also a constant.

12.3.1 Open path particles

The HBM suggests that harmonic closed path particles can be split into a new harmonic open path particle and an open path particle. The reverse is also possible. In these processes the number of hops is reserved. An empty harmonic closed particle is a nil object.

This means that an open path particle can be split from a composite that contains a fixed number closed path particles and a closed path harmonic particle.
That same open path particle can join a fixed number closed path particle and form an “oscillating” composite. The interacting open path particles do not carry e-charge. Also the closed path harmonic particles do not carry e-charge.

12.3.2 e-charge

The step stones do not carry the e-charge property. Instead the full fixed number closed path particle carries

this e-charge and neither the closed path harmonic particles nor the open path particles carry e-charge.

12.3.3 Harmonic closed path particles

A special category of closed path particles exists that have a variable number of contributing location holders[14]. They represent harmonic oscillations and they normally occur with a fixed number closed path particle in a composite.

A free fixed number particle can join an open path particle and become a composite of two closed path particles. At these occurrences the change of energy is compensated by emitting or absorbing an open path particle.

Variable number closed path particles do not carry e-charge.

12.3.4 Strings

Despite the fact that we discuss open and closed path particles, this is not a version of what usually is considered as string theory.

12.4 Hop conservation laws

In the above described conversion processes, the number of hops is always conserved. The number of hops in

[14] These particles have great resemblance with neutrinos.

closed path particles seem to correspond to what in contemporary physics is called the rest-mass part of the total energy of the particle. Besides of its rest-mass the particle has kinetic energy.
The number of hops in an open path particle is not called mass because these step stones do not curve the embedding continuum.

12.4.1 Free volume of space

A free volume of space is a region that is surrounded by a surface that is not passed by hops.

12.4.2 Number of hops.

In a free volume of space, the number of hops is conserved. ***This corresponds to the conservation of energy***.

12.4.3 Sum of hops

In a free volume of space the sum of all hops is zero. ***This corresponds to the conservation of momentum.***

12.4.4 *Free composites*

Free composites reside in a subspace of the Hilbert space that is controlled by a task of the operating system. That subspace might but it must not correspond to a single compact volume of space.
Free building blocks are supposed to reside in a subspace of the Hilbert space that is controlled by a task of

the operating system. That subspace must correspond to a single compact volume of space.
Here space is formed by the continuum eigenspace of the location operator, which resides in the Gelfand triple.

12.5 Movements

The particle can move in many different ways.
Some movements are part of the planned swarm. These movements only occur in the realm of the OS and cannot be observed.

12.5.1 Harmonic oscillation

In this view we take the position that the energy levels of the shell of an atom are carried by the individual electrons that constitute this shell.

In some conditions a particle exists in a mode that can be interpreted as an harmonic oscillation. This can occur in a range of modes that each corresponds to a discrete oscillation energy.

What happens can be understood in two ways. The first interpretation is that the oscillation energy increases the number of hops. This is possible when the oscillation is carried by a special closed path particle that contains a variable number of hops. Together with the original fixed number closed path particle this harmonic particle

forms a composite that has a larger number of hops than the non-oscillating particle. These constituents will be managed by two parallel subtasks of the OS.

Adding harmonic oscillation energy to such a composite can occur by absorbing the energy of an open path particle that contains the corresponding number of extra hops. Decreasing oscillation energy occurs by emitting energy in the form of an open path particle.

The second interpretation is that somehow an actual oscillation takes place. From observations and experiments we know that the oscillation energy levels correspond with modes of spherical harmonic oscillations. On the other hand these oscillations are NOT observable. The explanation can be that the harmonic oscillations occur in the preparation phase that takes place in the realm of the OS. Only the extra hops become observable.

12.5.2 Movement varieties

Due to movement of its complete swarm an open micropath unfolds to a condition that leads to a maximum speed in the condition that all folds are arranged along a part of a single geodesic. In that condition it moves at maximum speed c.

This not only holds for building blocks. It also holds for composites, but there it holds per constituent. The same maximum speed must hold for all constituents.

Due to movement of its complete swarm a closed micro-path particle may stretch until it approaches maximum speed. In that condition it runs completely along a part of a geodesic. Due to relativistic effects, this way of unfolding encounters resistance that increases with speed.

A non-oscillating closed micro-path particle may superpose with another closed path particle that represents a harmonic oscillation. Together they form a composite. The swarm covers the whole composite.

All closed path particles resists unfolding. In its most stable condition the closed micro-path is maximally folded. In that case the swarm is considered at rest.

12.5.3 Relativity

m is the total energy. ***According to relativity theory*** the energy of the swarm at rest is m_r where[15]

$$m_r^2 = m^2 - \left(m\,\frac{v}{c}\right)^2$$

[15] See section on relativistic energy and momentum.

$$m = \frac{m_r}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

Here v is a real number. Thus if v approaches c, then the total energy m goes to infinity.
Thus completely unfolding the micro-path is effectively made impossible by the operating system.

The rest energy/mass is contained in the number of hops. The kinetic energy is contained in the second term. It represents the costs of stretching closed path particles.

12.6 Interpretation

The swarm has a built-in mechanism that resists the unfolding of the closed particle part of the micro-path.

Breaking the temporary closed micro-path cycle of the combination of particle and antiparticle results in two open path particles that move in opposite directions.

12.7 Atoms and generations

In the electron clouds of atoms these composites appear to oscillate in an harmonic way around a center of gravity that is determined by the nucleus.

Oscillation around its own center of gravity may result in higher energy versions of the same kind of closed path particle.

13 Elementary particle hypothesis

13.1 Elementary coupling equation

In this section we ignore the existence of generations.

The great mutual similarity combined with the diversity that is observed for elementary particles suggests that this diversity is caused by a small set of rules. Elementary particle types are discerned by a very small number of properties: Rest mass, electric charge, spin and color charge.

The coupling equation for the electron and the positron as it is depicted by Paul Dirac, gives us a lead how to interpret this equation for other types of elementary particles.

The electron is an elementary particle and the question arises whether this particular form of the coupling equation is characteristic for elementary particles.

The HBM suggests that elementary particles are the result of couplings between the members of a special symmetry flavor bundle that is formed by continuous density distributions.

One of the members represents the quantum state function of the particle. It plays the role of the distribution that

has been prepared by a task of the OS. It will be mapped onto the embedding continuum. The other field plays the role of the resulting map.

Thus the coupling equation for elementary particles will be:

$$\nabla\psi^x = m\psi^y \tag{1}$$

The elementary antiparticle equation will be

$$\nabla^*(\psi^x)^* = m(\psi^y)^* \tag{2}$$

Here the symmetry flavors of functions ψ^x and ψ^y correspond to the symmetry flavors of two members of the symmetry flavor bundle that constitutes the Palestra. This limits the choice to functions that have the same real part. This choice enables the existence of 8x8=64 different types of particles whose properties depend on the coupled symmetry flavors.

We consider two categories of particles.

1. The ***F-category*** couples the symmetry flavor of the quantum state function to the reference symmetry flavor of the embedding

continuum, which is also the reference symmetry flavor of the special symmetry flavor bundle.

2. Other particles belong to the ***B-category***.

Contemporary physics has shown that a significant difference exists between these two categories.

The F-category particles correspond to discrete location distributions (swarms) whose elements are eigenvalues of eigenvectors of the location operator that is used by the operating system. These eigenvectors span the subspace that represents the particle.

13.2 Elementary particle characteristics

Now we have collected sufficient ammunition in order to tackle what coupling means. In the elementary coupling equation, one of the pair $\{\psi^x, \psi^y\}$ will act as the source and the other ψ^x will act as the drain.

The dimensions in which the symmetry flavors differ determine what the meaning of source and drain will be.

13.2.1 Categories and spin

We will give the reference symmetry flavor a preference status.

This will single out a category of elementary particles that can be characterized by the pair $\{\psi^x, \psi^{⓪}\}$. We call

this category the F-category[16]. Alternative particles belong to the B-category[17].

Anti-particles obey the antiparticle coupling equation. In analogy to the Dirac equation, the F-category anti-particles are characterized by the pair

$$\left\{(\psi^{x})^{*},\left(\psi^{⓪}\right)^{*}\right\}=\left\{(\psi^{x})^{*},\psi^{⑦}\right\}. \qquad (1)$$

The F-category is generated in a way that differs from the way that the B-category is generated. As a consequence these categories show different spins.

The F-category particles have half integer spin.

The B-category particles have integer spin.

Later a suggestion is given why that is the case.

The standard model contains only particle types that can be discerned by measuring results.

The HBM scheme discerns on symmetry related properties and does not mind whether they can be discerned by measurements.

[16] This refers to fermions.

[17] This refers to bosons.

13.2.2 e-charge

The dimensions in which the symmetry flavors differ determine the other characteristics of the elementary particle.

The HBM uses one third of the electric charge of the positron as its e-charge unit.

The e-charge equals the number of different dimensions between the x-symmetry flavor and the y-symmetry flavor. The sign of the e-charge count is switched if the handedness differs.

13.2.3 c-charge

The color of the participating fields results in the coloring for the resulting particle. Since the embedding field for F-category is neutral the coloring of the particle types is straight forward for members of this category.

B-category types can be multi-colored.

13.3 The HBM scheme

13.3.1 F-category

We do not yet treat generations.
According to the standard model, the F-category exists in three generations.
The F-category concerns 8 particle types and 8 anti-particle types.

13.3.1.1 Leptons

Leptons are color neutral.

13.3.1.1.1 Electrons and positrons

The electrons and positrons are easily comprehensible. They are isotropic (color neutral) particles.

Pair	s-type	e-charge	c-charge	Handedness	SM Name
$\{\psi^{⑦}, \psi^{⓪}\}$	fermion	-3	N	**LR**	electron
$\{\psi^{⓪}, \psi^{⑦}\}$	Anti-fermion	+3	W	**RL**	positron

13.3.1.1.2 Neutrinos

Neutrinos are the most difficult to understand elementary particles. Their quantum state function has the same symmetry flavor as the embedding continuum has.

type	s-type	e-charge	c-charge	Handedness	SM Name
$\{\psi^{⑦}, \psi^{⑦}\}$	fermion	0	NN	**RR**	neutrino
$\{\psi^{⓪}, \psi^{⓪}\}$	anti-fermion	0	WW	**LL**	neutrino

The HBM gives a suggestion for neutrinos as being closed path harmonic particles. They differ from other closed path type massive elementary particles in the fact that their number of hops is determined by a mechanism that acts like a spherical harmonic oscillation.

13.3.1.2 Quarks

Pair	s-type	e-charge	c-charge	Handed-ness	SM Name
$\{\psi^{①}, \psi^{⓪}$	fermion	-1	R	**LR**	down-quark
$\{\psi^{⑥}, \psi^{⑦}$	anti-fermion	+1	$\overline{\mathrm{R}}$	**RL**	Anti-down-quark
$\{\psi^{②}, \psi^{⓪}$	fermion	-1	G	**LR**	down-quark
$\{\psi^{⑤}, \psi^{⑦}$	anti-fermion	+1	$\overline{\mathrm{G}}$	**RL**	Anti-down-quark
$\{\psi^{③}, \psi^{⓪}$	fermion	-1	B	**LR**	down-quark
$\{\psi^{④}, \psi^{⑦}$	anti-fermion	+1	$\overline{\mathrm{B}}$	**RL**	Anti-down-quark
$\{\psi^{④}, \psi^{⓪}$	fermion	+2	$\overline{\mathrm{B}}$	**RR**	up-quark
$\{\psi^{③}, \psi^{⑦}$	anti-fermion	-2	B	**LL**	Anti-up-quark
$\{\psi^{⑤}, \psi^{⓪}$	fermion	+2	$\overline{\mathrm{G}}$	**RR**	up-quark

$\{\psi^{②},\psi^{⑦}$	Anti-fer-mion	-2	G	**LL**	Anti-up-quark
$\{\psi^{⑥},\psi^{⓪}$	fermion	+2	$\overline{R}$	**RR**	up-quark
$\{\psi^{①},\psi^{⑦}$	anti-fer-mion	-2	R	**LL**	Anti-up-quark

13.3.2 B-category

13.3.2.1 W-particles

The W-particles are multi-colored.

In the HBM scheme exist 9 different W_+-like particles and 9 corresponding anti-particles and 9 different W_- -like particles and 9 corresponding anti-particles.
The standard model discerns only one W_+-like particle and one W_--like particle.

Pair	s-type	e-charge	c-charge	Hand-ed-ness	SM Name
$\{\psi^{⑥},\psi^{①}\}$	boson	-3	$\overline{\mathrm{R}}\mathrm{R}$	**RL**	W_-
$\{\psi^{①},\psi^{⑥}\}$	anti-boson	+3	$R\overline{\mathrm{R}}$	**LR**	W_+
$\{\psi^{⑥},\psi^{②}\}$	boson	-3	$\overline{\mathrm{R}}\mathrm{G}$	**RL**	W_-
$\{\psi^{②},\psi^{⑥}\}$	anti-boson	+3	$G\overline{\mathrm{R}}$	**LR**	W_+
$\{\psi^{⑥},\psi^{③}\}$	boson	-3	$\overline{\mathrm{R}}\mathrm{B}$	**RL**	W_-
$\{\psi^{③},\psi^{⑥}\}$	anti-boson	+3	$B\overline{\mathrm{R}}$	**LR**	W_+
$\{\psi^{⑤},\psi^{①}\}$	boson	-3	$\overline{\mathrm{G}}\mathrm{G}$	**RL**	W_-
$\{\psi^{①},\psi^{⑤}\}$	anti-boson	+3	$\mathrm{G}\overline{\mathrm{G}}$	**LR**	W_+

$\{\psi^{⑤},\psi^{②}\}$	boson	-3	$\overline{\mathrm{G}}\mathrm{G}$	**RL**	W_{-}
$\{\psi^{②},\psi^{⑤}\}$	anti-boson	+3	$\mathrm{G}\overline{\mathrm{G}}$	**LR**	W_{+}
$\{\psi^{⑤},\psi^{③}\}$	boson	-3	$\overline{\mathrm{G}}\overline{\mathrm{B}}$	**RL**	W_{-}
$\{\psi^{③},\psi^{⑤}\}$	anti-boson	+3	$\mathrm{B}\overline{\mathrm{G}}$	**LR**	W_{+}
$\{\psi^{④},\psi^{①}\}$	boson	-3	$\overline{\mathrm{B}}\mathrm{R}$	**RL**	W_{-}
$\{\psi^{①},\psi^{④}\}$	anti-boson	+3	$\mathrm{R}\overline{\mathrm{B}}$	**LR**	W_{+}
$\{\psi^{④},\psi^{②}\}$	boson	-3	$\overline{\mathrm{B}}\mathrm{G}$	**RL**	W_{-}
$\{\psi^{②},\psi^{④}\}$	anti-boson	+3	$\mathrm{G}\overline{\mathrm{B}}$	**LR**	W_{+}
$\{\psi^{④},\psi^{③}\}$	boson	-3	$\overline{\mathrm{B}}\mathrm{B}$	**RL**	W_{-}
$\{\psi^{③},\psi^{④}\}$	anti-boson	+3	$\mathrm{B}\overline{\mathrm{B}}$	**LR**	W_{+}

13.3.2.2 Z-particles

Z-particles are multi-colored.

In the HBM scheme exist 6 different Z-like particles and 6 different Z-like anti-particles.
The standard discerns only one Z-like particle and one Z-like anti-particle.

Pair	s-type	e-charge	c-charge	Hand-ed-ness	SM Name
$\{\psi^{②},\psi^{①}\}$	boson	0	GR	**LL**	Z
$\{\psi^{⑤},\psi^{⑥}\}$	anti-boson	0	$\overline{\mathrm{G}}\overline{\mathrm{R}}$	**RR**	Z
$\{\psi^{③},\psi^{①}\}$	boson	0	BR	**LL**	Z
$\{\psi^{④},\psi^{⑥}\}$	anti-boson	0	$\overline{\mathrm{R}}\overline{\mathrm{B}}$	**RR**	Z
$\{\psi^{③},\psi^{②}\}$	boson	0	BR	**LL**	Z
$\{\psi^{④},\psi^{⑤}\}$	anti-boson	0	$\overline{\mathrm{R}}\overline{\mathrm{B}}$	**RR**	Z
$\{\psi^{①},\psi^{②}\}$	boson	0	RG	**LL**	Z
$\{\psi^{⑥},\psi^{⑤}\}$	anti-boson	0	$\overline{\mathrm{R}}\overline{\mathrm{G}}$	**RR**	Z
$\{\psi^{①},\psi^{③}\}$	boson	0	RB	**LL**	Z
$\{\psi^{⑥},\psi^{④}\}$	anti-boson	0	$\overline{\mathrm{R}}\overline{\mathrm{B}}$	**RR**	Z
$\{\psi^{②},\psi^{③}\}$	boson	0	RB	**LL**	Z
$\{\psi^{⑤},\psi^{④}\}$	anti-boson	0	$\overline{\mathrm{R}}\overline{\mathrm{B}}$	**RR**	Z

13.3.2.3 Other particles

Until now we have treated particles that may represent the particles that are recognized in the standard model. The shown HBM set already contains more particles

than the SM discerns. Since the “extra” bosons only differ in their multi-color charge, which cannot yet be measured, these particles may represent SM-particles.

However, we have only treated 8 F-category particles and 8 F-category anti-particles.
The B-category represents 9 versions of the W_+-particle and 9 versions of the W_--particle. Further it contains 6 potential representatives of the Z-particle. The versions only differ in their multi-color charge.

Thus result 64-16-18-12 = 18 “other particles”. Thus, if multi-color cannot be observed, then the shown part of the HBM scheme equals the standard model.
The open path particles are not covered in this overview. They contain 2 photons and 6 gluons.

14 Mapping the swarm

14.1 The allocation function

The planned swarm is mapped on a member of the Palestra that acts as the embedding continuum.
The mapping can be described by a continuous quaternionic allocation function $\wp$.
This quaternionic allocation function$\wp$ describes a path through (part of) the history of the Palestra. This path partly describes the live of the corresponding building block.
The allocation function has a flat parameter space, which is formed by rational quaternions. The real part of these parameters represents progression. For each particle, $\wp$ uses a separate parameter value. The spatial image of $\wp$ varies with this parameter value and thus with progression.

With other words, in combination with its full parameter space, $\wp$ describes the target embedding continuum and the movement of the particle in this continuum.

14.1.1 Metric

The differential of the allocation function describes a quaternionic metric. This metric describes the curvature of the Palestra.

$$ds(q) = ds^{\nu}(q)e_{\nu} = d\wp = \sum_{\mu=0\ldots3} \frac{\partial\wp}{\partial q_{\mu}} dq_{\mu} = c^{\mu}(q)dq_{\mu} \tag{1}$$

q is the quaternionic location.
ds is the metric.
c^{μ} is a quaternionic function.

Pythagoras:

$$c^2dt^2 = ds\, ds^* = dq_0^2 + dq_1^2 + dq_2^2 + dq_3^2 \tag{2}$$

Minkowski:

$$dq_0^2 = d\tau^2 = c^2\, t^2 - dq_1^2 - dq_2^2 - dq_3^2 \tag{3}$$

In flat space:

$$\Delta s_{flat} = \Delta q_0 + \boldsymbol{i}\, \Delta q_1 + \boldsymbol{j}\, \Delta q_2 + \boldsymbol{k}\, \Delta q_3 \tag{4}$$

In curved space:

$$\Delta s_{\wp} = c^0\, \Delta q_0 + c^1\, \Delta q_1 + c^2\, \Delta q_2 + c^3\, \Delta q_3 \tag{5}$$

$d\wp$ is a quaternionic metric
It is a linear combination of 16 partial derivatives

$$d\wp = \sum_{\mu=0\ldots3} \frac{\partial \wp}{\partial q_\mu} dq_\mu = c^\mu(q) dq_\mu \tag{6}$$

$$= \sum_{\mu=0\ldots3} \sum_{\nu=0,\ldots3} e_\nu \frac{\partial \wp_\nu}{\partial q_\mu} dq_\mu = \sum_{\mu=0\ldots3} \sum_{\nu=0,\ldots3} e_\nu c_\nu^\mu dq_\mu$$

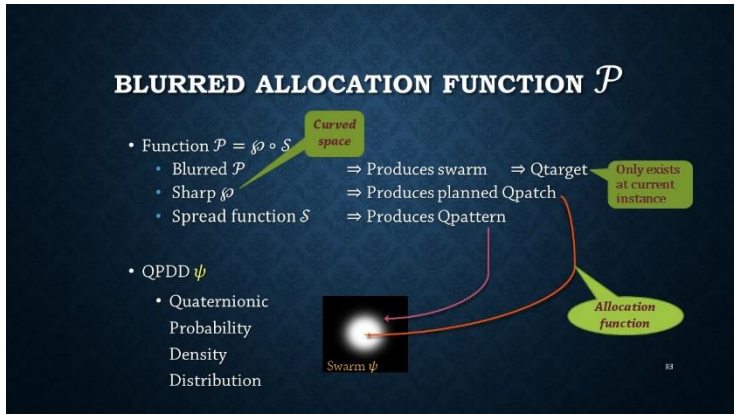
14.2 The blurred allocation function

The real part of the parameter of the allocation function $\wp$ represents progression. This progression value is used as enumerator value by the stochastic spatial spread function.

The blurred allocation function $\mathcal{P}$ describes the combined effect of the allocation function $\wp$ and the stochastic spatial spread function $\mathcal{S}$. The combination is a convolution.

$$\mathcal{P} = \wp \circ \mathcal{S} \tag{1}$$

Like $\wp$, $\mathcal{P}$ uses for each separate particle a single rational quaternion as a parameter and produces the current location of that particle. $\wp$ produces the center location of the complete mapped swarm.



14.3 Names giving

The ***planned swarm*** will be called ***Qpattern***. It is produced by stochastic spatial spread function $\mathcal{S}$.

The Qpattern is mapped onto the embedding continuum by the allocation function $\wp$. There it becomes the ***virtual swarm***.

The target of the allocation function $\wp$ for a given particle is called ***Qpatch***.

The target for the blurred allocation function $\mathcal{P}$is the current location of the particle and it is called ***Qtarget***.

The blurred allocation function $\mathcal{P}$ produces a virtual swarm. The Qtarget is the only actual location in this swarm.

A continuous quaternionic density distribution ψ characterizes the virtual swarm. This means that the corresponding discrete distribution is characterized by the same symmetry flavor and by statistical characteristics. The real part of the continuous density distribution corresponds to the squared modulus of the wave function of the particle. That is why we call ψ the ***quaternionic quantum state function*** of the particle.

15 Embedding process

The embedding recurs at every progression step.
At every progression step the embedding of a single building block can be interpreted as the arrival of the particle at a new location.

15.1 What happens?

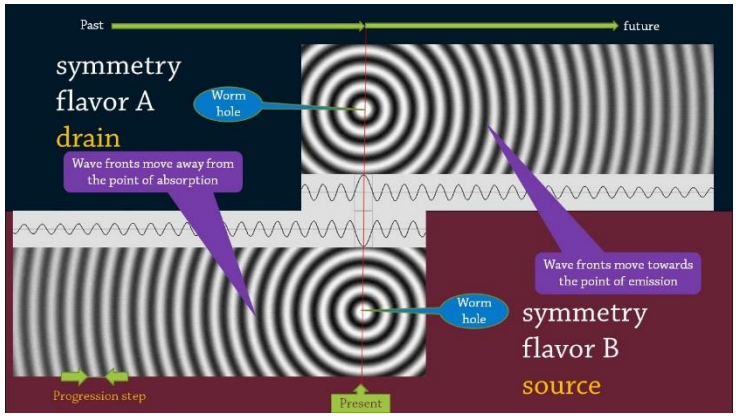
The elementary coupling equation describes the coupling for a free elementary particle.
One member of a symmetry flavor bundle couples to another member. The coupling can be interpreted as follows:

At the location of the coupling a small amount of space is exchanged from the source member to the drain member. The drain member acts as the embedding continuum. The source member acts as representative of the planned swarm. This occurrence causes a ***local singularity*** in the drain member.

The coupling only lasts during a single progression step. The next coupling occurs at a slightly different location. The subsequent locations form a coherent swarm. It is the virtual image of the planned swarm. The ***influence*** of the singularity keeps spreading in the form of a wave

front that moves with the highest possible speed over the Palestra.

The wave fronts combine into ***super-high frequency waves.*** The frequency of these waves is so high that they ***cannot be observed.*** Only the ***averaged effects*** of these waves can be observed. These averaged effects form one of the ***potentials*** of the building block



In symmetry flavor A member, space is contracting towards the worm hole. In symmetry flavor B member, space is expanding away from the worm hole. The worm hole forms a common singularity. At the instance of embedding the collected space is transported via the worm hole from symmetry flavor A to symmetry flavor

B. At each progression step the worm hole appears at a slightly different location.

15.2 Different potentials

Potentials represent smoothed effects. The symmetry flavor is a swarm wide effect. That effect is not carried by the individual elements of the swarm. Thus information that is only contained in the full swarm is emitted in a different way. It becomes observable via different potentials. The micro structure of the element oriented potential and the structure of the swarm oriented potential will differ. The swarm oriented potential is centered around the Qpatch.

15.3 Wave fronts

At every arrival at a step stone, the building block emits a wave front that carries a message about it presence and its properties. These properties become visible in the potentials that are formed by the element oriented wave fronts. The element oriented wave fronts are isotropic.

The origin of space curvature is the fact that the element oriented wave fronts fold and thus curve the embedding continuum.
Together, these wave fronts form ***super-high frequency waves***

The propagation of the wave fronts is controlled by ***Huygens principle***
For isotropic wave fronts their ***amplitude*** decreases with the inverse of the distance to their source.

Swarm oriented wave fronts may cover a number of dimensions that depends on the involved symmetry flavors.
The effect of the Huygens principle depends on the number of involved dimensions. The form of the Green's function is determined by the Huygens principle. The Green's function determines the ***contribution*** of the corresponding wave front(s) to the potential.

Depending on dedicated ***Green's functions***, the integral over the wave fronts constitutes a series of ***potentials***.

Gravitation potentials and electrostatic potentials have different Green's functions. This already indicates that the potentials have fundamentally different origins.

The gravitation potential uses a charge distribution that is constituted from the contributions of the separate swarm elements. The electrostatic potential uses a charge that is constituted by the discrete symmetry properties of this whole distribution. At small scales also the form of the Green's functions differ.

15.4 Potentials

Potentials are the averaged effects of the wave fronts that are emitted during the coupling that forms the building block

The wave fronts and the potentials are traces of the particle and its used step stones.
The superposition of the singularities smoothens the effect of these singularities.
Neither the emitted wave fronts, nor the potentials affect the particle that emitted the wave front
Wave fronts interfere.
The wave fronts modulate a field

The wave fronts that correspond to the gravitation potential, fold and thus curve the embedding continuum.

The wave fronts that correspond to the electrostatic potential do not curve the embedding continuum. Their influence is determined by the e-charge of the particle. Here the quaternionic equivalent of the Maxwell equations describe the situation. The e-charge is determined by the complete swarm and is not located in the location holders that form the elements of the swarm.

16 Binding

16.1 Binding mechanism

The fourth swarming condition enables the application of the superposition principle in the realm of Fourier space.
In this way the superposition coefficients become displacement generators
The consequence is that these coefficients may define movements that are internal to the composite. Such movements are oscillations.

16.2 Composites

The fact that superposition coefficients define internal movements can best be explained by formulating the definition of composites as follows.

Composites are equipped with a quantum state function whose Fourier transform at any progression step equals the superposition of the Fourier transforms of the quantum state functions of its constituents.

Now the superposition coefficients define internal displacements. As a function of progression they define internal oscillations.

16.3 Internal kinetics

Within free elementary building blocks the internal movements concern the micro-path and the harmonic oscillation of the building block. The harmonic oscillation is represented by a separate closed path particle. The harmonic oscillation itself is hidden. The extra particle becomes observable via its contribution to the number of embedded locations that represent the elementary building block.

Within composites the internal movements concern oscillations of the constituting bounded elementary building blocks.
With other words, the harmonic particles represent packs of superposition coefficients.

16.4 Coupling equation

Like elementary particles, composites obey ***the swarming conditions***
For composites the coupling equation holds

$$\Phi = \nabla\psi = m\,\varphi \tag{1}$$

ψ and φ are normalized quaternionic functions that represent density distributions.

16.5 Geoditches

Each of the elements of the swarm causes a local ***pinch*** that describes the temporary (singular) curvature of the embedding continuum. In a free elementary particle the swarm of pinches combine in a non-singular ***pitch***.

If the internal movements of the constituents inside a composite are harmonic oscillations, then these oscillations are represented by extra swarm elements.

In a composite the micro-paths of the constituting elementary particles are folded along the internal movement paths. In the composite these internal movements combine the ***pinches*** into ***ditches*** that like the micro-paths fold along the movement paths. These ditches form special kinds of geodesics that we will call ***"Geoditches".***
Together with the extra swarm elements, the geoditches explain the binding effect of the superposition of the constituents.

In a small composite, such as a nucleus or an atom, the geoditches might blur the oscillations with up-and-down hops to such an extent, that the oscillations are no longer recognizable. For electrically charged constituents this means that the oscillations of the charge do not generate corresponding EM waves! However,

the hops and the oscillations contribute to the internal kinetic energy and in this way they contribute to the total energy m of the free composite. Further the whole swarm that represents the composite represents the integrated e-charge.

Another explanation is that internal harmonic oscillations of the swarm only occur in the realm of the operating system and only become noticeable by the extra hops and the integrated e-charge that occur in the mapped swarm.

17 Wave front propagation

At the instant of the embedding of an elementary particle a wave front is emitted in the embedding continuum. This wave front slightly folds and thus curves that medium. These wave fronts cannot be observed. However their averaged effects can become noticeable as the potentials of the particle. In order to investigate these phenomena we must study the propagation of the wave fronts.

At every progression step, each existing elementary particle emits a wave front. Each emission departs from a different step stone. Each wave front contributes to the potentials of the particle. The contribution of the wave front to the potential is described by a dedicated Green's function. The Green's function is determined by the Huygens principle.

The elements of the swarm only send wave fronts in three dimensions. The swarm as a whole may send wave fronts in one, two or three dimensions.

Thus two types of wave fronts are emitted:

- Swarm element related wave fronts.
  - Always cover 3 dimensions
  - The "charge"is the energy of the element.
- Full swarm related wave fronts.
  - May cover 1, 2 or 3 dimensions
  - The charge is the e-charge of the swarm

In each of these cases the Huygens principle acts differently.

17.1 Huygens principle

The propagation of waves is governed by the Huygens principle. The operating system uses this mechanism in order to regenerate all wave fronts at every progression step.

17.1.1 Huygens principle for odd and even number of spatial dimensions

The following is taken from http://www.math-pages.com/home/kmath242/kmath242.htm

The spherically symmetrical wave equation in n spatial dimensions can be written as

$$\frac{\partial^2\psi}{\partial r^2} + \frac{n-1}{r}\frac{\partial\psi}{\partial r} = \frac{\partial^2\psi}{\partial t^2} \tag{1}$$

Now suppose we define a new scalar field ϕ by the relation

$$\phi(r,t) = r^{(n-1)/2}\psi(r,t) \tag{2}$$

This leads to

$$\frac{\partial^2\phi}{\partial r^2} + \frac{(n-1)(n-3)}{4r^2}\phi = \frac{\partial^2\phi}{\partial t^2} \tag{3}$$

If n equals 1, meaning that we have just a single space dimension, then the second term on the left hand side vanishes, leaving us with a one-dimensional wave equation, with has the well-known general solution

$$\psi(r,t) = f(r-t) + g(r+t) \tag{4}$$

for arbitrary functions f and g.

if n equals 3, i.e., in the case of three spatial dimensions, the spherically symmetrical wave equation reduces

again to a one-parametric wave equation, in the modified wave function $\phi = r\psi$. Hence the general solution in three space dimensions is

$$\psi(r,t) = \frac{f(r-t)}{r} + \frac{g(r+t)}{r} \tag{5}$$

The fact that this solution is divided by r signifies that the magnitude of the wave tends to drop as r increases (unlike the one-dimensional case, in which a wave would theoretical propagate forever with non-diminished strength). Focusing on just the "retarded" component of the wave, $f(r-t)/r$, the fact that the time parameter t appears only in the difference $r-t$ implies that the (attenuated) wave propagates in time with a phase velocity of precisely 1, because for any fixed phase β we have $r - t = \beta$ and so dr/dt for this phase point is 1. Consequently if f is a single pulse, it will propagate outward in a spherical shell at precisely the speed 1, i.e., on the light cone. Conversely, it can be shown that the wave function at any point in space and time is fully determined by the values and derivatives of that function on the past light cone of the point.

Any wave equation for which this is true (i.e., for which disturbances propagate at a single precise speed) is said

to satisfy Huygens' Principle. The connection with Huygens' original statement about secondary wavelets is that each wavelet - with the same speed as the original wave - represents a tiny light cone at that point, and Huygens' principle asserts that light is confined to those light cones.

For n equals 2 the extra term in equation (3) does not vanish. We can still solve the wave equation, ***but the solution is not just a simple spherical wave front*** propagating with unit velocity. Instead, we find that there are effectively infinitely many velocities, in the sense that a single pulse disturbance at the origin will propagate outward on infinitely many "light cones" (and sub-cones) with speeds ranging from the maximum down to zero. Hence if we lived in a universe with two spatial dimensions (instead of three), an observer at a fixed location from the origin of a single pulse would "see" an initial flash but then the disturbance "afterglow" would persist, becoming less and less intense, but continuing forever, as slower and slower subsidiary branches arrive.

17.1.2 The case of even spatial dimensions

Now again start from equation (1) and try a solution in the form:

$$\psi(r,t) = f(r)g(t) \tag{1}$$

Inserting this into the wave equation and expanding the derivatives by the product rule gives

$$g\frac{\partial^2 f}{\partial r^2}+\frac{n-1}{r}g\frac{\partial f}{\partial r}=f\frac{\partial^2 g}{\partial t^2} \tag{2}$$

Dividing through by fg gives

$$\frac{1}{f}\frac{\partial^2 f}{\partial r^2}+\frac{n-1}{f\,r}\frac{\partial f}{\partial r}=\frac{1}{g}\frac{\partial^2 g}{\partial t^2} \tag{3}$$

This decouples into two equations

$$\frac{\partial^2 f}{\partial r^2}+\frac{n-1}{r}\frac{\partial f}{\partial r}=k\,f \tag{3}$$

And

$$\frac{\partial^2 g}{\partial t^2}=k\,g \tag{4}$$

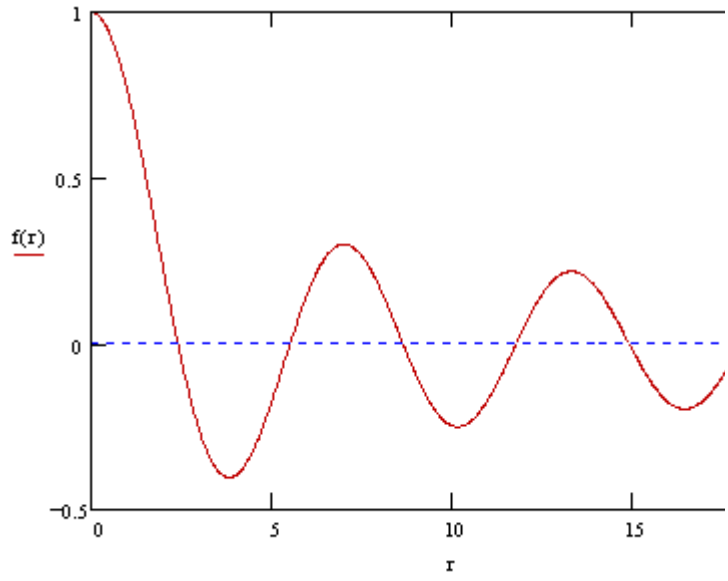
If k is positive or zero the right hand equation gives "run-away" solutions for $g(t)$, whereas if k is negative we can choose scaling so that $k=-1$ and then $g(t)$ satisfies the simple harmonic equation, whose solutions include functions of the form $sin(ct)$ and $cos(ct)$. In that case equation (9) can be re-written in the form

$$r\frac{\partial^2 f}{\partial r^2} + (n-1)\frac{\partial f}{\partial r} + r\,f = 0 \tag{5}$$

This is the form of a Bessel's equation. In fact for n=2 the solution is the zero order Bessel function $J_0(r)$.

$$J_0(r) = \frac{2}{\pi}\int_0^{\infty} \sin(\cosh(\theta)\,r)\,d\theta \tag{6}$$

A plot of $J_0(r)$ is shown below.



Inserting $g(t) = sin(ct)$ gives

$$\psi(r,t) = \frac{1}{\pi}\int_0^\infty [\cos(\cosh(\theta)\, r - ct) - \cos(\cosh(\theta)\, r + ct)]\, d\theta \tag{7}$$

Hence, instead of the solution being purely a function of $r \pm ct$ as in the case of odd dimensions, we find that it is an integral of functions of $cosh(\theta)r \pm ct$. Each

value of θ corresponds to a propagation speed of $c/cosh(\theta)$, so the speeds vary from c down to zero. This signifies that the wave function at any event is correlated not just with the wave function on its "light cone", but with the wave function at every event inside its light cone.

In two dimensions the Huygens principle corresponds to a centripetal force[18] with potential

$$V = -\frac{\hbar}{8Mr^2}. \tag{8}$$

17.1.3 Huygens principle applied

Form the swarm related wave fronts hold:

HYPOTHESIS : *Particles transmit waves in dimensions where the discrete symmetry of the quantum state function differs from the discrete symmetry of the embedding background.*

The operating system uses the Huygens principle in order to initiate the potentials at each progression step. The Huygens principle works differently depending on

[18] http://cds.cern.ch/record/514621/files/0108083.pdf

the number of dimensions in which the waves are transmitted.

The characteristics of the potentials that are emitted or absorbed by elementary particles are determined by the differences between the discrete symmetry set of the quantum state function of the particle and the symmetry set of the coupled QPDD that represents the embedding continuum. This difference determines whether the potentials act in 1, 2 or 3 dimensions. In odd dimensions the persistence of the potentials can be explained by the common interpretation of the Huygens principle. This common interpretation is that at every point of each wave front new waves are generated. This does not work for particles that send their waves in two dimensions. This includes some types of quarks, W-particles and Z-particles. The corresponding messengers are gluons. For these objects the potentials also act in two dimensions. In even dimensions the Huygens principle does not act in its normal way.

The same conditions that determine whether waves are emitted in 1, 2, or 3 dimensions also determine whether the particle has 1, 2 or 3 units of e-charge.
The re-emitted waves consist out of a retarded component and an advanced component. These components correspond to outbound interactions and inbound interactions.

17.2 Discussion

The particular behavior of the Huygens principle for potential contributions that cover even dimensions might explain the exceptional strength of the corresponding strong force mechanism.

It appears that fermions with e-charges of $\pm$n units produce n dimensional waves that contribute to their electrostatic potential.
For n=3 the Green's function is of form 1/r.
For n=2 the Green's function is a zero order Bessel function.
For n=1 the Green's function is a constant.

On the other hand the color confinement principle[19] prevents that the even dimensional actions of the Huygens principle will become observable in a long lasting way. The gravitation potential is not influenced by the discrete symmetries of the swarm. The corresponding potential contributions are always transmitted isotropic in three dimensions.

The electrostatic potential is controlled by the discrete symmetry sets. Depending on the resulting electric charge of the particle the electric potential contributions are transmitted in 1, 2 or 3 dimensions.

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[19] See color confinement.

The operating system applies the Huygens principle for the generation of wave fronts that form the gravitation potential in each progression step.

The operating system applies the Huygens principle for the generation of wave fronts that form the electrostatic potential at each swarm generation cycle.

17.3 Green's functions

No general mathematical solution is known for the conversion to a rather static potential function of a super-high frequency train of wave fronts that start at slightly different positions. However, for a Gaussian distribution of charges a rather simple solution is known.

17.4 Gravity and electrostatics

In this comparison of 3D potentials we use the fact that already at a small distance a potential that has the form $Erf(r)/r$ takes the shape of $1/r$.

Potentials depend on the Green's function that is used to convert the corresponding density distribution into a potential function. Apart from their Green's function, gravity and electrostatics can be treated by similar equations.

Description	***Gravity***	***Electrostatics***
Field	$\boldsymbol{g} = -\boldsymbol{\nabla}\,\varphi$	$\boldsymbol{E} = -\boldsymbol{\nabla}\,\varphi$
Force	$\boldsymbol{F} = m\boldsymbol{g}$	$\boldsymbol{F} = Q\boldsymbol{E}$
Gauss law	$\langle \boldsymbol{\nabla}, \mathrm{g} \rangle = -4\pi G\rho$	$\langle \boldsymbol{\nabla}, \mathrm{E} \rangle = \frac{Q}{\varepsilon}$
Poisson law $\Delta\varphi = \langle \boldsymbol{\nabla}, \boldsymbol{\nabla}\varphi \rangle$	$\Delta\varphi = 4\pi G\rho$	$\Delta\varphi = -\frac{Q}{\varepsilon}$
Greens function	$\frac{-\rho(\boldsymbol{r}')}{\lvert \boldsymbol{r} - \boldsymbol{r}' \rvert}$	$\frac{q}{\lvert \boldsymbol{r} - \boldsymbol{r}' \rvert}$
Single charge potential	$\varphi = -\frac{4\pi G m}{\lvert \boldsymbol{r} \rvert}$	$\varphi = \frac{Q}{4\pi\varepsilon \lvert \boldsymbol{r} \rvert}$
Single charge field	$g = -\frac{4\pi G m}{\lvert \boldsymbol{r} \rvert^2}\boldsymbol{r}$	$\boldsymbol{E} = \frac{Q}{4\pi\varepsilon \lvert \boldsymbol{r} \rvert^2}\boldsymbol{r}$

Two charge force	$\boldsymbol{F} = -\frac{4\pi G m_1 m_2}{\lvert\boldsymbol{r}\rvert^3}\boldsymbol{r}$	$\boldsymbol{F} = \frac{Q_1 Q_2}{4\pi\varepsilon\lvert\boldsymbol{r}\rvert^3}\boldsymbol{r}$
Mode	**attracting**	**repelling**

The table shows that the Greens functions of both fields differ in sign. For the gravitation potential the Green's function is charged with the local "charge" density $\rho(\boldsymbol{r}')$. As a consequence at small scales, the Green's function looks like an $Erf(r)/r$ function. At larger scales it approaches the $1/r$ form. For the electrostatic potential the Green's function is charged with a (constant) electric charge Q.

In comparison: The Yukawa potential[20] uses a short range Green's function:

$$\frac{-\rho(\boldsymbol{r}')}{|\boldsymbol{r}-\boldsymbol{r}'|}\exp(-\mu|\boldsymbol{r}-\boldsymbol{r}'|) \tag{1}$$

[20] http://en.wikipedia.org/wiki/Yukawa_potential

In this example we use the gravitational Green's function.

Since the items are carriers with charge ρ_i, the density distribution$\rho_f(\mathbf{r})$ correspond to a potential $\varphi(\boldsymbol{r})$.
Every item contributes a term $\varphi_i(\boldsymbol{r}-\boldsymbol{r_i}) = \frac{-\rho_i}{|\boldsymbol{r}-\boldsymbol{r_i}|}$

$$\varphi(\boldsymbol{r}) = \sum_i \varphi_i(\boldsymbol{r}-\boldsymbol{r_i}) = \sum_i \frac{-\rho_i}{|\boldsymbol{r}-\boldsymbol{r_i}|}$$

Example: If there is a static spherically symmetric Gaussian charge density

$$\rho_g(r) = \frac{\rho_c}{\sigma^3\sqrt{2\pi}^3}\exp(\frac{-r^2}{2\sigma^2})$$

where ρ_c is the total charge, then the solution $\varphi(r)$ of Poisson's equation,

$$\nabla^2\varphi = \rho_g$$

is given by

$$\varphi(r) = \frac{\rho_c}{4\pi\varepsilon r}\,\mathrm{erf}\left(\frac{r}{\sqrt{2}\sigma}\right) = \frac{-1}{4\pi\varepsilon}\int \frac{\rho_g(\boldsymbol{r'})}{|\boldsymbol{r}-\boldsymbol{r'}|}\,d^3\boldsymbol{r'}$$

where $erf(x)$ is the error function.

Note that, for r much greater than σ, the erf function approaches unity

17.4.1 Interpretation

The above integral can be interpreted as a summation of influences by all step stones that constitute the micro-path of the particle.
Thus the potential of the (Gaussian) particle is given by:

$$\varphi(r) \approx \frac{\rho_c}{4\pi\varepsilon r}\,\mathrm{erf}\left(\frac{r}{\sqrt{2\sigma}}\right) \tag{1}$$

This no longer represents a singularity[21].

17.4.2 Bertrand's theorem

Now we remember Bertrand's theorem.[22] :

Bertrand's theorem states that only two types of central force potentials produce stable, closed orbits:

(1) an inverse-square central force such as the gravitational or electrostatic potential

$$V(r) = \frac{-k}{r} \tag{1}$$

[21] See figure in 11.3.
[22] http://en.wikipedia.org/wiki/Bertrand's_theorem.

and

(2) the radial harmonic oscillator potential

$$V(r) = \tfrac{1}{2}\, k\, r^2 \qquad (2)$$

According to this investigation it becomes acceptable to assume that the undisturbed shape of the Qpatterns can be characterized by something that comes close to a 3D Gaussian distributions. Since such a distribution produces the correct shape of the gravitation potential***, the underlying mechanism would explain the origin of curvature***.

17.5 Smoothing the singularity

The electrostatic potential still shows a singular potential. However, its "charge" is blurred by the full swarm. Thus it might be proper to use the form $Erf(r)/r$ also for the form of the Green's function of the electrostatic potential.

18 Operating system hypothesis

This chapter partly uses facts that follow from the HBM and for another part it uses facts that are known from contemporary physics. These latter facts are colored blue.

18.1 Operating system task

The operating system confines its task to a selected set of closed subspaces of the Hilbert space. Each of these selected Hilbert space subspaces represents a free construction element.

Free construction elements may merge via superposition into higher order construction elements. In that case the constituents are no longer free elements.

Free construction elements can also disintegrate in lower order free construction elements that previously were bounded construction elements,

The lowest order free construction elements exist in three categories:

1. Closed path elements that feature a fixed number of hops.
    a. This number may be a global constant.

    b. This number may depend on the type of the building object.
2. Closed path elements that feature a variable number of hops.
    a. This number may vary during the life of the element.
3. Open path elements that feature a variable number of hops.
    a. This number is constant during the life of the element.

The number of hops that occur in variable number of hops elements corresponds with the oscillation modes of harmonic oscillations.

The second kind of elements may convert into the third kind of elements and vice versa.

Further free construction elements can be divided into two categories:

- F-type construction elements
    - When these objects become bounded construction elements, then the composite cannot contain more than one of these elements that has the same

properties. This corresponds to the Pauli principle.
    - F-type elementary particles are represented by the eigenvectors of an allocation operator.
    - In the free composite perturbation within each pair of F-type elements causes a switch of sign of the state function of the composite.
    - F-type elements feature half-integer spin.
    - F-type elementary particles couple their quantum state function to the reference element of the Palestra.
- B-type construction elements.
    - The B-type elements do not feature the restrictions of the F-type elements.
    - B-type elements feature integer spin.

18.2 Operating system cycle time

It is quite possible that like free building blocks, also free composites are prepared in seclusion in a special

flat continuum before they are mapped to the target continuum, which is a curved field.

The regeneration cycle time is defined as the number of progression steps that the generation process of a free particle or a free composite takes for its completion.

It looks as if the actions of the operating system are restricted by a fixed cycle time. Several regeneration actions may occur in parallel.

Thus the OS contains a parallel task scheduler.

This becomes clear when elementary particles are investigated. When at rest, elementary particles are supposed to contain a fixed number of hops. When they operate as part of free composites, then they combine with other constructs that represent oscillations that are internal to the free composite. Also these constituents are generated according to the task scheme of the OS. These parallel tasks must besynchronized.

The oscillation representatives are not the traditional elementary particles. The difference is that this kind of objects does not possess a fixed number of hops.

The particles that represent harmonic oscillations might also exist as free building blocks. They are closed path

particles that may contain a variable number of hops. The number is constant during the lifetime of the particle. Their reproduction cycle time corresponds to the standard reproduction cycle time.
The recycle period represents a temporal frequency.

It might be considered that regeneration cycle time depends on particle type or that regeneration of constituents occurs in series rather than in parallel. However, such measures would significantly complicate the regeneration process. It is in conflict with the fact that all massive elementary particles can annihilate by producing photons and the fact that photons can create massive elementary particles, while photons encode their energy into their frequency. The HBM suggests a standard regeneration cycle time and The HBM suggests that regeneration of constituents occurs in parallel.

18.2.1 Two recycle periods

This suggestion corresponds to a fixed recycle period for Hilbert vectors and another fixed recycle period for the subspaces that are spanned by these Hilbert vectors. Thus the regeneration cycle period of closed subspaces does not depend on the number of Hilbert vectors that span the subspace. This is solved by sub-tasks that ***act in parallel***. These sub-tasks ***work in seclusion***. The sub-tasks ***work in sync***. They use their ***own symmetry flavor***.

18.3 Elementary F-type category particles

Elementary F-type category particles are represented by eigenvectors of a privileged normal operator. The selected closed subspace that is supported by the OS is spanned by the representatives of such elementary F-type category particles. This is the reason why in a free composite all elementary F-type particle have unique eigenvalues.

19 Superposition

In a composite superposition of elementary particles can be considered in configuration space and it can be considered in Fourier space. At each progression instant these superposition coefficients may differ. With other words they are functions of progression. The Fourier transform $\mathcal{F}$ is a linear operator.

$$\mathcal{F}\big(\, g(q)\big) = \;\tilde{g}(p) \tag{1}$$

$$\mathcal{F}(a\; g(q) + b\; h(q)) = \; a\; \tilde{g}(p) + b\; \tilde{h}(p) \tag{2}$$

With a superposition in Fourier space the superposition coefficients can be interpreted as displacement generators.

$$\begin{aligned} \mathrm{g}(q) = \nabla f(q) = \; & \nabla_0 f_0(q) \mp \langle \boldsymbol{\nabla}, \boldsymbol{f}(q) \rangle \\ & \pm \nabla_0 \boldsymbol{f}(q) + \; \boldsymbol{\nabla} f_0(q) \\ & \pm \big(\pm \boldsymbol{\nabla} \times \boldsymbol{f}(q) \big) \end{aligned} \tag{3}$$

$$\begin{aligned} \tilde{\mathrm{g}}(k) = \mathrm{k}\tilde{f}(k) = \; & \mathrm{k}_0 \tilde{f}_0(k) \mp \langle \mathbf{k}, \tilde{\boldsymbol{f}}(k) \rangle \\ & \pm \mathrm{k}_0 \tilde{\boldsymbol{f}}(k) + \; \mathbf{k} \tilde{f}_0(k) \\ & \pm \big(\pm \mathbf{k} \times \tilde{\boldsymbol{f}}(k) \big) \end{aligned} \tag{4}$$

Thus superposition coefficients that are a function of progression can implement internal oscillations of the constituents.
The internal oscillation paths become internal geoditches. Together these geoditches implement the binding of the elementary particles into the composite.
On the other hand the geoditches obscure the locations of the constituents. The hopping inside the micro-paths also disturbs the generation of EM radiation.
With other words the identity of the constituents is hidden from the environment of the composite.

19.1 Superposition coefficients

Quaternionic number systems exist in 16 symmetry flavors. This becomes apparent when sets of quaternions or quaternionic functions are prepared in seclusion. The seclusion is broken when mixed arithmetic is applied. The same holds for handling continuous quaternionic functions.

As a consequence the HBM uses its reference symmetry flavor for handling superposition coefficients.

In addition to this, a map of a set of discrete objects into an embedding continuum must always choose the reference symmetry flavor as its embedding target.

19.2 Entanglement

The fact that the quantum state function of the composite equals the superposition of the quantum state functions of the constituents is usually interpreted as the entanglement of the constituents inside the composite. It means that the closed subspace that represents the composite equals the conjunction of the subspaces that represent the constituents. The composite is represented by a normalized probability density function. In this way the location density distribution have become the slaves of the location density distribution of the composite.

19.3 Pauli principle

Fermions are particles whose locations at every instance of progression are represented by eigenvectors of the location operator. The closed subspace that represents this fermion is spanned by these eigenvectors. If two fermions belong to a composite, then they must be represented by different eigenvectors.

If two components of an entangled (sub)system that have the same quantum state function are exchanged, then we can take the system location at the center of the location of the two components. Now the exchange means for bosons that the (sub)system quantum state function is not affected:

$$\forall_{\alpha,\beta}\{\alpha\varphi(-x)+\beta\varphi(x)=\alpha\varphi(x)+\beta\varphi(-x)\}$$
$$\Rightarrow \varphi(-x)=\varphi(x)$$

And for fermions that the corresponding part of the (sub)system quantum state function changes sign.

$$\forall_{\alpha,\beta}\{\alpha\varphi(-x)+\beta\varphi(x)=-\alpha\varphi(x)-\beta\varphi(-x)\}$$
$$\Rightarrow \varphi(-x)=-\varphi(x)$$

This conforms to the Pauli principle. It also indicates that the operating system, which controls the entanglement, takes care of the fact that if one of these two twin components exposes any of its properties (e.g. its spin) that it has IMMEDIATE effect on the properties of the other component.

19.4 Gauge transformations

In quaternionic quantum mechanics the superposition of elementary particles achieve what in complex quantum mechanics displacement gauge transformations will do. When the change of the quaternionic superposition coefficients restricts to phase shifts, then the change represents a complex gauge transformation.

20 Non-locality

Within the Hilbert Book Model the notion of non-locality exists. This is due to the fact that point-like particles

hop along a micro-path of step stones that covers a region of space in a stochastic way. Further these particles may superpose, which makes them interdependent. These particles possess properties and the properties must fit with the interrelations of the constituents of the composite.

20.1 Within a particle

The swarms that represent nature's building blocks may extend over a significant region. At any of its step stones the particle will show its individual set of properties.

So measuring the same property at nearly the same instant at quite different locations will give the same result.

However, ***on average***, the hops will not jump faster than the speed of information transfer.

Apart from the property measurements, in this process no information transfer needs to take place.

At each arrival at a step stone the building block transmits contributions to its potentials. If the measurement

uses these potentials, then the building block is not affected by the measurement[23].

According to this explanation, at least one progression step must separate the two measurements.

20.2 Within compact composites

Non-locality between particles means that the reach of control of the operating system covers multiple elementary particles. This can be caused by the fact that the particles are considered to form a an entangled composite. In that system the Pauli principle will take its role. It means that if the constituting particles are fermions, then at all progression instances they must al take different states. This sounds familiar in composites such as atoms, but it can also happen in other entangled systems.

The coupling of entangled particles and the support of the Pauli principle are supported by special capabilities of the operating system.

20.3 The action range of the OS

The operating system may show a larger action range than is shown by free building blocks or by compact composites. In that case non-locality can cover large

[23] It is also possible that the first measurement is used in order to prepare the state of the particle.

distances. It still means that participating building blocks must superpose.

21 Lorentz transformation

21.1 Reference frames

Differences between positions in subsequent members of the sequence of HBM pages can be interpreted as displacements. The displacement is a coordinate transformation. For the properties of this transformation it does not matter where the displacement starts or in which direction it is taken.

The same holds for displacements that concern sequence members that are located further apart. The corresponding displacements form a group. The displacement is a function of both the position and the sequence number. The sequence number is represented by the progression step number.

The Lorentz transform concerns the sequence of Hilbert spaces and NOT the Gelfand triple. With other words the transform does not concern the field that represents space! The reference frames that are treated here are pairs of locations and progression step numbers. These are discrete objects. For simplicity the next section treats them as quaternions that have real, rather than rational coefficients.
The locations are locations of swarms (Qpatches) and not locations of step stones (Qtargets).

21.2 The transformation

The displacement $\tau, z \rightarrow \tau', z'$ can be interpreted as a coordinate transformation and can be described by a matrix. Here τ is progression and it is the real part of the quaternion. z represents the imaginary part of the quaternion. Both quaternions concern characteristic data of a single complete swarm. From the previous chapter we know that the dynamics of the swarm is limited by a maximum speed c. The condition of the swarm at the two reference frames can be represented by a matrix.

$$\begin{bmatrix} \tau' \\ z' \end{bmatrix} = \begin{bmatrix} \gamma & \delta \\ \beta & \alpha \end{bmatrix} \begin{bmatrix} \tau \\ z \end{bmatrix} \tag{1}$$

The matrix elements are interrelated. When the displacement concerns a uniform movement, the interrelations of the matrix elements become a function of the speed v. Here v is the speed measured as displacement per progression interval. The group properties together with the isomorphism of space fix the interrelations.

$$\begin{bmatrix} \tau' \\ z' \end{bmatrix} = 1/\sqrt{1 + kv^2} \begin{bmatrix} 1 & kv \\ -v & 1 \end{bmatrix} \begin{bmatrix} \tau \\ z \end{bmatrix} \tag{2}$$

If k is positive, then there may be transformations with $kv^2 \gg 1$ which transform progression into a spatial co-

ordinate and vice versa. This is considered to be ***unphysical***. The Hilbert book model also supports that vision.

The condition k = 0 corresponds to a ***Galilean transformation***

$$\begin{bmatrix}\tau' \\ z'\end{bmatrix} = \begin{bmatrix}1 & 0 \\ -v & 1\end{bmatrix}\begin{bmatrix}\tau \\ z\end{bmatrix} \tag{3}$$

The condition $k < 0$ corresponds to a Lorentz transformation. We can set $kc^2 = -1$, where c is an invariant speed that corresponds to the maximum of v.

$$\begin{bmatrix}\tau' \\ z'\end{bmatrix} = 1/\sqrt{1 - v^2/c^2}\begin{bmatrix}1 & -v/c^2 \\ -v & 1\end{bmatrix}\begin{bmatrix}\tau \\ z\end{bmatrix} \tag{4}$$

$$\tau' = \frac{1}{\gamma}\left(\tau - \frac{vz}{c^2}\right)$$

$$z' = \frac{1}{\gamma}(z - v\,\tau)$$

$$\tau = \frac{z - \gamma\, z'}{v}$$

21.3 Phenomena

Lorentz transformations introduce the phenomena that go together with relativity, such as length contraction, progression dilatation and relativity of simultaneity that occur when two inertial reference frames are considered. Within an inertial reference frame Newton's first law holds and in our consideration all points move at the same speed.

$$\tau_1' = \frac{1}{\gamma}\left(\tau_1 - \frac{v z_1}{c^2}\right)$$

$$\tau_1' - \tau_2' = \frac{1}{\gamma}\left(\tau_{1-}\tau_2 - \frac{v(z_1 - z_2)}{c^2}\right)$$

With $z_1 = z_2$ this delivers:

$$\Delta\tau' = \frac{\Delta\tau}{\gamma}$$

This explains progression dilation

$$z_1' = \frac{1}{\gamma}(\mathrm{z}_1 - v\,\tau_1)$$

$$\Delta z' = \frac{\Delta z}{\gamma}$$

This explains length contraction.

These phenomena occur in the Hilbert Book Model when different members of the sequence of Hilbert spaces are compared. Usually the inertial frames are spread over a range of Hilbert book pages.
Since the members of the sequence represent static status quos and swarms are only defined within such a static status quo, the relativity of simultaneity restricts the selection of the inertial frames. Each of the inertial frames must be situated completely in a single member of the sequence.

The indicated phenomena arise when one inertial frame is observed from the other inertial frame.

21.4 Relativistic energy and momentum

The micro-path of the elementary particle stretches along the movement path. On the other hand, for observing objects the length in the direction of movement contracts. These effects compensate. Time dilation is not compensated.

The observing object gets its information via the wave fronts that at super-high frequency are emitted by the observed elementary particle. This super-high frequency cannot be observed.

Displacements of the considered moving particle will be observed to be smaller. Thus its momentum will be affected. Phenomena inside the realm of the particle run slower.
$\boldsymbol{p}$ and p_0 are both generators of increments of respectively $\delta\boldsymbol{q}$ and δq_0

$$\delta g = p\ \delta q$$

The real part of δg is used as the generator in the unitary transform, which is invariant against inversion[24].

$$\delta g_0 = p_0\ \delta q_0 - \langle \boldsymbol{p}, \delta \boldsymbol{q} \rangle$$

$$= \delta g_0' = p_0'\ \delta q_0' - \langle \boldsymbol{p}', \delta \boldsymbol{q}' \rangle$$

$$\delta q_0 = \frac{\delta q_0' - \langle \delta \boldsymbol{q}', \frac{\boldsymbol{v}}{c^2} \rangle}{\gamma}$$

[24] This approach was taken according to ideas of Shan Gao in his "Derivation of the energy momentum relation".

$$\delta \boldsymbol{q} = \frac{\delta \boldsymbol{q}^{'} - \boldsymbol{v}\, \delta q_0^{'}}{\gamma}$$

$$p_0\, \delta q_0 - \langle \boldsymbol{p}, \delta \boldsymbol{q} \rangle$$

$$= p_0\, \frac{\delta q_0' - \langle \delta \boldsymbol{q}', \frac{\boldsymbol{v}}{c^2} \rangle}{\gamma} - \langle \boldsymbol{p}, \frac{\delta \boldsymbol{q}' - \boldsymbol{v}\, \delta q_0'}{\gamma} \rangle$$

$$= \left(\langle \frac{\boldsymbol{p}}{\gamma}, \boldsymbol{v} \rangle + \frac{p_0}{\gamma} \right) \delta q_0' - \langle \frac{\boldsymbol{p}}{\gamma}, \delta \boldsymbol{q}' \rangle + \langle \frac{p_0}{\gamma} \frac{\boldsymbol{v}}{c^2}, \delta \boldsymbol{q}' \rangle$$

$$= \frac{\langle \boldsymbol{p}, \boldsymbol{v} \rangle + p_0}{\gamma} \delta q_0' - \langle \delta \boldsymbol{q}', \frac{\boldsymbol{p} + \frac{\boldsymbol{v}}{c^2}}{\gamma} \rangle$$

$$= p_0^{'}\, \delta q_0' - \langle \boldsymbol{p}^{'}, \delta \boldsymbol{q}' \rangle$$

$$\boldsymbol{p}' = \frac{\boldsymbol{p} + p_0 \frac{\boldsymbol{v}}{c^2}}{\gamma}$$

$$p_0' = \frac{\langle \boldsymbol{p}, \boldsymbol{v} \rangle + p_0}{\gamma}$$

These equations represent the relativistic energy and momentum equations.

The formulas can be reversed:

$$p_0 = \gamma p_0' - \langle \boldsymbol{p}, \boldsymbol{v} \rangle$$

$$\boldsymbol{p} = \gamma \boldsymbol{p}' - p_0 \frac{\boldsymbol{v}}{c^2}$$

$$p_0 = \gamma p_0' - \gamma \langle \boldsymbol{p}', \boldsymbol{v} \rangle + p_0 \frac{v^2}{c^2}$$

$$p_0 = p_0' - \langle \boldsymbol{p}', \boldsymbol{v} \rangle$$

$$\boldsymbol{p} = \gamma \boldsymbol{p}' - (\gamma p_0' - \langle \boldsymbol{p}', \boldsymbol{v} \rangle) \frac{\boldsymbol{v}}{c^2}$$

21.5 Analyzing the imaginary part of the generator

The imaginary part of the generator δf might also be invariant.

$$\delta f = p\,\delta q$$

$$\delta \boldsymbol{f} = \boldsymbol{p}\,\delta q_0 + p_0\,\delta \boldsymbol{q} + \boldsymbol{p} \times \delta \boldsymbol{q}$$

$$\delta \boldsymbol{f} = \delta \boldsymbol{f}'$$

So let us investigate whether:

$$\boldsymbol{p}\,\delta q_0 + p_0\,\delta \boldsymbol{q} + \boldsymbol{p} \times \delta \boldsymbol{q}$$

$$\stackrel{?}{=} \boldsymbol{p}'\,\delta q_0' + p_0'\,\delta \boldsymbol{q}' + \boldsymbol{p}' \times \delta \boldsymbol{q}'$$

$$= \boldsymbol{p}\,\frac{\delta q_0' - \langle \delta \boldsymbol{q}', \frac{\boldsymbol{v}}{c^2} \rangle}{\gamma} + p_0\,\frac{\delta \boldsymbol{q}' - \boldsymbol{v}\,\delta q_0'}{\gamma} + \boldsymbol{p} \times \frac{\delta \boldsymbol{q}' - \boldsymbol{v}\,\delta q_0'}{\gamma}$$

Or:

$$\boldsymbol{p}'\,\delta q_0' + p_0'\,\delta \boldsymbol{q}' + \boldsymbol{p}' \times \delta \boldsymbol{q}'$$

$$\stackrel{?}{=} \left(\gamma \boldsymbol{p}' - (p_0' - \langle \boldsymbol{p}', \boldsymbol{v} \rangle)\frac{\boldsymbol{v}}{c^2}\right)\frac{\delta q_0' - \langle \delta \boldsymbol{q}', \frac{\boldsymbol{v}}{c^2} \rangle}{\gamma}$$

$$+\left(p_0^{'}-\langle \boldsymbol{p}^{'},\boldsymbol{v}\rangle\right)\frac{\delta \boldsymbol{q}'-\boldsymbol{v}\,\delta q_0'}{\gamma}$$

$$+\left(\gamma \boldsymbol{p}'-\left(p_0'-\langle \boldsymbol{p}',\boldsymbol{v}\rangle\right)\frac{\boldsymbol{v}}{c^2}\right)\times\frac{\delta \boldsymbol{q}^{'}-\boldsymbol{v}\,\delta q_0^{'}}{\gamma}$$

Or:

$$\left(p_0'-\langle \boldsymbol{p}',\boldsymbol{v}\rangle\right)\frac{\boldsymbol{v}}{c^2}\frac{\langle \delta \boldsymbol{q}^{'},\frac{\boldsymbol{v}}{c^2}\rangle}{\gamma}+\langle \boldsymbol{p}',\boldsymbol{v}\rangle\frac{\boldsymbol{v}\,\delta q_0^{'}}{\gamma}$$

$$+\left(p_0'-\langle \boldsymbol{p}',\boldsymbol{v}\rangle\right)\frac{\boldsymbol{v}}{c^2}\times\frac{\boldsymbol{v}\,\delta q_0^{'}}{\gamma}\stackrel{?}{=}\boldsymbol{0}$$

Or:

$$p_0'\stackrel{?}{=}\left(1+\frac{c^4\,\delta q_0^{'}}{\langle \delta \boldsymbol{q}^{'},\boldsymbol{v}\rangle}\right)\langle \boldsymbol{p}',\boldsymbol{v}\rangle$$

This does not seem to be generally valid for all values of δq and p. The conclusion is that the invariance only holds for the real part of the generator δg.

22 Movement in an embedding field

We use the strategy that Denis Sciama applied in his "On the origin of inertia"[25].
An elementary particle represents an artifact in its embedding continuum. The "strength" of the artifact can be characterized by the total energy m, which acts as a charge in a surrounding field. Here the field equations for charged object apply. This consideration also holds for composites.

The influence of the charge is determined by the Green's function. For a free moving elementary particle that shows a Gaussian density distribution of its location swarm this Green's function has a shape:

$$\frac{Erf(r)}{r}$$

Already at a small distance from the center this can be approached by

$$\frac{1}{r}$$

[25] http://www.adsabs.harvard.edu/abs/1953MNRAS.113...34S

Together with the strength m this corresponds to a potential.

$$\varphi = \iiint_V \frac{\rho}{\boldsymbol{r}}\, dV$$

Here ρ represents the "charge" density distribution of the contributing N "charges" of (average) size m/N to the potential φ.

$$\varphi \propto m$$

$$\varphi = g\, m$$

g is a proportionality factor.
A uniformly moving potential with speed $\boldsymbol{v}$ corresponds to a vector potential $\boldsymbol{A}$.

$$\boldsymbol{A} = \iiint_V \frac{\rho}{\boldsymbol{r}} \boldsymbol{v}\, dV = \varphi\, \boldsymbol{v}$$

$$A = \phi + \varphi\, \boldsymbol{v}$$

ϕ is the scalar part of the embedding field $\boldsymbol{A}$.
$\boldsymbol{A}$ is the imaginary part. We will use the quaternionic differential field equations.

If the scalar potential φ accelerates, then this goes together with a new vector field $\boldsymbol{E}$.

$$\frac{\partial A}{\partial \tau} = \frac{\partial \phi}{\partial \tau} + \frac{\partial \varphi}{\partial \tau}\, \boldsymbol{v} + \varphi\, \dot{\boldsymbol{v}}$$

We separate the imaginary part of this equation:

$$\frac{\partial \boldsymbol{A}}{\partial \tau} = \frac{\partial \varphi}{\partial \tau}\, \boldsymbol{v} + \varphi\, \dot{\boldsymbol{v}}$$

Further we know:

$$E_0 = \frac{\partial \phi}{\partial \tau} - \langle \boldsymbol{\nabla}, \boldsymbol{A} \rangle$$

$$\boldsymbol{E} = \frac{\partial \boldsymbol{A}}{\partial \tau} + \boldsymbol{\nabla}\phi + \boldsymbol{\nabla} \times \boldsymbol{A} \tag{6}$$

$$\boldsymbol{E} = \frac{\partial \varphi}{\partial \tau}\, \boldsymbol{v} + \varphi\, \dot{\boldsymbol{v}} + \boldsymbol{\nabla}\phi + \boldsymbol{\nabla} \times \boldsymbol{A}$$

All terms on the right side, except the second term are very small.

$$\boldsymbol{E} \approx \varphi\, \dot{\boldsymbol{v}} = g\, m\, \dot{\boldsymbol{v}}$$

Thus the acceleration goes together with an extra vector field ***E*** that counteracts the acceleration of the moving potential. In physical terminology ***E*** is a force field. In fact ***E*** represents the action of ***inertia***.

With other words the fact that elementary particles emit wave fronts, whose averaged effect is noticeable as a gravitation potential, results in the existence of inertia. This effect represents itself as a force field.

23 Photons

The HBM offers multiple possibilities.

23.1 Basic phenomena

It is not yet clear why the maximum speed of building blocks *c* conforms to the maximum speed of information transfer. For that reason we must investigate the photons, which are the carriers of that information.

The rest mass of photons equals zero. They may progress in space for billions of years and after that they can still be detected by a suitable detector. They can be interpreted as one dimensional wave fronts. With other words they are governed by the one dimensional Huygens principle. Their sources may emit the photons in isotropic patterns, but each separate photon is a one dimensional wave front.
The photons are emitted in energy quanta that have a discrete energy, which is encoded in the number of hops of the photon. This indirectly relates to the frequency of the photon.

Atoms may emit photons. The electrons that belong to the atom appear to travel in oscillation paths that are hidden by the geoditches, which are produced by these oscillating electrons. Due to this coverage the electromagnetic radiation that normally would be emitted, does

not appear. The up and down hopping in the micro-path completely disturbs the generation of the EM radiation. However, the kinetic energy of the oscillation adds to the kinetic energy of the hops and thus it adds to the total energy of the electron and as a consequence it adds to the mass of the atom.
A more appropriate explanation would be that the oscillations do not occur in the Palestra, but instead they occur during the preparation phase in the realm of the operating system.
Only the corresponding extra hops become noticeable in the embedding continuum.

23.2 Photon emission

If the electron switches to a lower energy oscillation mode, then a corresponding photon is emitted.

The HBM suggests that this emission takes the completion of a full micro-path, which has a fixed duration. That time is used to encode the energy jump into the photon. However, it is also possible that the oscillation energy is contained in an extra harmonic closed path particle that superposes with the non-oscillating fixed number closed path particle. In this way the harmonic particle presents a set of superposition coefficients that cause non-observable spherical oscillations.

The amplitudes of the regeneration wave fronts diminish with progression, but the photon wave front keeps its amplitude. The photon hops travel with the wave fronts.

In order to produce the one-dimensional wave front or series of wave fronts, the electron must emit the photon from nearly the same location and in exactly the same direction.

23.2.1 Explanation

The situation can simply be explained, however that explanation has strong implications.

The elementary particle can obtain extra hops by participating in a harmonic oscillation. The number of extra hops corresponds to the energy of the oscillation. This extra energy is represented by a closed path particle that together with the fixed number closed path particle forms a composite. When a photon is emitted it takes a part of these extra hops as its bunch of energy. The extra hops are sent in a fixed progression interval. Thus the energy is encoded in the number of hops of the photon. This indirectly relates to the frequency of the photon. The photon is the emitted open path particle.

During this special cycle of the micro path, the electron emits the photon in a preselected direction. The emission means that the closed path harmonic particle loses part of its elements that depart as a photon. After this procedure the virtual oscillation restarts in the other oscillation mode.

The duration of the special micro-path cycle must not differ from the standard micro-path cycle. Also the harmonic oscillation must not influence the duration of the micro-path cycle. This can be explained when a special particle that owns a variable set of hops, represents the oscillation and superposes with the fixed number closed path particle. Further, their regeneration must occur in parallel.

Harmonic oscillation energy is related to the number of hops in a micro-path cycle.

If this explanation fits, then this is a strong indication that the duration of the regeneration of elementary particles is fixed.
This is a requirement that is posed by the regeneration of composites. For composites the regeneration of its composites must occur in sync.

23.2.2 Relation with neutrinos

The closed path particles that represent harmonic oscillation have great resemblance with what we know of neutrinos. If this suggestion strikes truth, then the closed path particles that represent harmonic oscillations can also occur as free particles.

23.3 Cosmological red shift

The speed of information transfer relates the basic progression step with a basic spatial step. If one of these basic factors is a constant, then a change of one of the others also induces a change of the third factor.

In contemporary physics it is generally accepted that the speed of information transfer is an eternal and universe wide constant. With this premise a red shift as a function of progression of photon emission line structures is leading to the conclusion that space is expanding.
The HBM supposes that the speed of information transfer is a universe wide constant that may gradually change with progression. This opens the possibility that the non-observable basic progression step can be taken as a model wide constant. The alternative of a fixed progression step would be that a special mechanism must be introduced that controls the gradual change of the basic progression step. By accepting a model wide constant progression step the reason must be given why the

space of information transfer changes with progression. This explanation can be found in the temporal behavior of the map of the Hilbert space onto the Gelfand triple.

Due to red shift the wave length of the photon changes, but the number of progression ticks that the passage of this train of wave fronts will take stays constant. With other words the number of hops is conserved. This means that the energy of the photon is related to the number of its hops instead of to its frequency. At each instant of progression the energy of a photon is related to its frequency.

23.4 Photon absorption

Photon absorption is the reverse of photon emission. At the arrival of a fitting photon the current oscillation and the regeneration of the elementary particle enter a special regeneration cycle in which the hops of the photon are added to the hops of the elementary particle. During the special cycle of the micro-path the photon energy is absorbed. Next the oscillation is restarted in the new oscillation mode.

24 Creation and annihilation

24.1 Annihilation of elementary particles

We only treat a simple case.
The annihilation of a closed path elementary particle involves the merger of a particle and an anti-particle in a composite, which subsequently results in the emission of all hops into two photons that have the same frequency and that when the composite is at rest will leave in opposite directions. This complicated procedure is enforced by conservation laws.

24.2 Creation of elementary particles

We only treat a simple version.
The creation of a closed path elementary particle pair involves the absorption of the hops of two photons that have the same frequency and arrive from nearly opposite directions. The result is a composite that splits into a particle and an anti-particle.
The created composite is at rest with respect to the frame in which the photons have opposite directions. This complicated procedure is enforced by conservation laws.

24.3 Other oscillations

According to observations made by contemporary physics, creation and annihilation can also occur with other

particles than photons as the absorbed or emitted objects. For example W-particles and Z-particles act as such oscillatory objects.

25 Detection patterns

The wave nature of free elementary particles and photons can be visualized by their detection patterns. Both free elementary particles and photons can be characterized by the probability density distribution of their potential detection locations. This probability density distribution has a Fourier transform. As a consequence the probability density distribution is a wave package.

The shape of the actual probability density distribution is affected by space curvature and by boundary conditions. Since these conditions change with progression, the actual probability density distribution is also a function of progression. Thus the movement path of the considered object plays an important role.

Large sets of nearly similar objects that have such density distributions may show interference of the waves that are contained in the wave packages. As a consequence the detection patterns may take the form of interference patterns. This gives the impression that the separate objects show wave behavior. However, this behavior only appears when sets of similar objects interfere and they are the result of the interaction of the probability density distributions of the particles and the boundary conditions. The potentials of the objects may

interact and as such the potentials of other objects are part of the boundary conditions of the considered object.

If a trail of elementary particles that all are prepared in the same way passes a given potential configuration or an aperture configuration[26], then the geometric configuration of these boundary conditions acts as an imaging mechanism.

The configuration of this imaging mechanism has an Optical Transfer Function that affects the resulting probability density distribution that defines the detection probability of the objects that are being imaged. The OTF is the Fourier transform of the geometric potential or aperture configuration.

The Fourier transform of the probability density distribution of the considered object is the mapping quality characteristic of that object.

At every progression instant the product of this OTF and the mapping quality characteristic of a moving object determine the resulting detection density probability distribution of the moving object.

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[26] An aperture configuration is a special type of potential configuration.

At the instant of detection, part of the influencing distributions is moving with the detected object, while the other part is rather static and represents the boundary conditions. At every progression instant their Fourier transforms multiply in order to form the Fourier transform of the effective probability density distribution. The object just obeys the restrictions that are set by this final distribution.

For a set of objects the angular distributions and the distribution of properties such as color (for photons), energy and charge play a role. A homogeneous set gives a different detection pattern than an inhomogeneous set.

26 Spin suggestion

26.1 The micro-path

The ***micro-path*** can be walked ***in two directions***
The micro-path may implement a ***quasi rotation***
The both the swarm and the path define a swarm ***movement step.***
A closed micro-path can still be stretched along movement path. A fixed number closed path particle can superpose with an harmonic closed path particle.

26.2 The generation of the swarm

The generation of a planned swarm is started by a Poisson process that delivers a germ. This germ is used by the subsequent binomial process that is implemented by a 3D spread function. The spread function uses a spherical coordinate system, which can be characterized by three parameters. They are used in one of two sequences:

1. The zenith vector r
    a. The germ selects the value of r.
2. The polar angle φ.
    a. The polar angle axis is perpendicular on the zenith vector
    b. The polar angle has range 0 to 2π
3. The azimuth angle axis (θ range π)

    a. The azimuth angle axis is perpendicular on
        i. the zenith vector
        ii. polar angle axis
    b. The azimuth angle has range 0 to π

In this case the spin vector is along the azimuth angle.

Or the parameters are used in the sequence:

1. The zenith vector r
    a. The germ selects the value of r.
2. The azimuth angle axis (θ range π)
    a. The azimuth angle axis is perpendicular on
        i. the zenith vector
        ii. polar angle axis
    b. The azimuth angle has range 0 to π
3. The polar angle φ.
    a. The polar angle axis is perpendicular on the zenith vector
    b. The polar angle has range 0 to 2π

In this case the spin vector is along the polar angle.

26.2.1 The spin axis

The spin axis can be along the φ axis, which leads to half integer spin or along the θ axis which leads to integer spin.

27 The unit speed path

A difference exists between the description of the ***planned micro-path*** and the ***Frenet Serret*** description of the unit speed path of the swarm.

At any point in the ***Palestra*** and in any direction a path can be started
Also ***Qpatches*** that represent particles follow such paths
In the Palestra the "length" of the quaternionic path is the coordinate time duration

$$s(d) = \int_0^d \|d\wp\| = \int_0^d \left\|\frac{d\wp}{d\tau}\right\| d\tau$$

d is the ***duration*** in proper time ticks.
$\boldsymbol{\tau}$ is the ***progression*** parameter. It equals proper time.
s is the ***coordinate time***.

We investigate constant speed curves in the imaginary Palestra.
$\boldsymbol{\mathcal{R}}$ is the imaginary part of $\wp$**.**

$$\boldsymbol{T} = \frac{Im\left(\frac{d\wp}{ds}\right)}{\left\|Im\left(\frac{d\wp}{ds}\right)\right\|} = \frac{\frac{d\boldsymbol{\mathcal{R}}}{ds}}{\left\|\frac{d\boldsymbol{\mathfrak{R}}}{ds}\right\|}$$

$\boldsymbol{T}$ is the ***tangent unit vector***.

$$\boldsymbol{N} = \frac{\frac{d\boldsymbol{T}}{ds}}{\left\|\frac{d\boldsymbol{T}}{ds}\right\|}$$

$\boldsymbol{N}$ is the ***principle normal unit vector***.

Since $\|\boldsymbol{T}\| = 1$ are $\boldsymbol{N}$ and $\boldsymbol{T}$ perpendicular.

$$\boldsymbol{B} = \boldsymbol{T} \times \boldsymbol{N}$$

$\boldsymbol{B}$ is the ***binormal unit vector***
The sign of $\boldsymbol{T}, \boldsymbol{N}$, and $\boldsymbol{B}$ depends on the discrete symmetry set of the embedding field.

27.1 Path characteristics

$$\frac{d\boldsymbol{T}}{ds} = \kappa\, \boldsymbol{N}$$

κ is the curvature.

$$\frac{d\boldsymbol{N}}{ds} = -\kappa\, \boldsymbol{T} + \tau\, \boldsymbol{B}$$

τ is the torque.

$$\frac{d\boldsymbol{B}}{ds} = -\tau\,\boldsymbol{N}$$

28 Modular construction

28.1 Basic modular construction law

The basic modularization law installs modular construction of composites from elementary building blocks.

At any progression instant, all discrete constructs in physical reality can be represented by a closed subspace of a single separable Hilbert space

However, the effects of modular construction go much further than is ensured by this basic modularization law.

28.2 Modularization

Modularization is a very powerful influencer. Together with the corresponding ***encapsulation*** it has a very healthy influence on the ***relational complexity*** of the ensemble of objects on which modularization works.
The encapsulation takes care of the fact that most relations are kept internal to the module.

When relations between modules are reduced to a few types, then the module becomes ***reusable***.

The most influential kind of modularization is achieved when modules can be ***configured from lower order modules***.

Elementary particles can be considered as the lowest level of modules. All composites are higher level modules.

When ***sufficient resources*** in the form of reusable modules are present, then modularization can reach enormous heights.
On earth it was capable to generate ***intelligent species***.

28.2.1 Complexity

Potential relational complexity of a set of objects is a measure that is defined by the number of potential relations that exist between the members of that set.

If there are n elements in the set, then there exist n*(n-1) potential relations.

Actual relational complexity of a set of objects is a measure that is defined by the number of relevant relations that exist between the members of the set.

In human affairs and with intelligent design it takes time and other resources to determine whether a relation is relevant or not. Only an expert has the knowledge that a given relation is relevant.
Thus it is advantageous to have as little irrelevant potential relations as is possible, such that mainly relevant and preferably usable relations result.

28.2.2 Relational complexity

We define ***relational complexity*** as the ratio of the number of actual relations divided by the number of potential relations.

28.2.3 Interfaces

Modules connect via interfaces.
Interfaces are used by interactions.
Interactions run via (relevant) relations.

Relations that act within modules are lost to the outside world of the module.

Thus interfaces are collections of relations that are used by interactions.
Inbound interactions come from the past.
Outbound interactions go to the future.
Two-sided interactions are cyclic. They are either oscillations or rotations of the inter-actor.

28.2.4 Interface types

Apart from the fact that they are inbound, outbound or cyclic the interfaces can be categorized with respect to the type of relations that they represent.
Each category corresponds to an ***interface type***.

An interface that possesses a type and that installs the possibility to couple the corresponding module to other modules is called a ***standard interface***.

28.2.5 Modular subsystems

Modular subsystems consist of connected modules. They need not be modules. They become modules when they are encapsulated and offer standard interfaces that makes the encapsulated system a reusable object.

The cyclic interactions bind the corresponding modules together.

28.2.5.1 Coupling in small composites

Like the coupling factor of elementary particles characterizes the binding of the pair of Qpatterns will a similar characteristic characterize the binding of modules. This binding characteristic directly relates to the total energy of the constituted sub-system.

Let ψ represent the renormalized superposition of the involved distributions. We treat the sources and drains separately.

$$\nabla\psi = \phi = m\,\varphi \tag{1}$$

$$\int_V |\psi|^2 \, dV = \int_V |\varphi|^2 \, dV = 1 \tag{2}$$

$$\int_V |\phi|^2 \, dV = m^2 \tag{3}$$

Here ψ represents a superposition of local sources, while φ represents a superposition of drains that themselves might reside at distant locations.

And for the anti-particles (that act as drains):

$$\nabla^* \psi_a^* = m \, \varphi_a^* \tag{4}$$

Here ψ_a^* represents a superposition of local drains, while φ_a^* represents a superposition of sources that themselves might reside at distant locations.

The whole composite contains both local sources and local drains that are neutralized by local and distant counterparts.
The corresponding integral equations must define a closed system.

The binding factor is the total energy of the sub-system minus the sum of the total energies of the separate constituents.

28.2.6 Quantum oscillations

An interaction that runs via information transfer always runs from a previous instant to a later instant. Bidirectional interactions must be cyclic. Thus, bidirectional interfaces between system components are formed by exchanging messages into two directions or by actual oscillations. Harmonic oscillations that are internal to the elementary particle, only become noticeable as extra hops that are part of a superposed closed path particle. In case of an interface consisting of (non-harmonic) oscillating elementary particles the micro-path of the particle is stretched along the oscillation path.

For an elementary particle at rest, the singularities that are caused by the step stones dig a potential well. In this way a particle creates its own inertia. In case of an oscillation, the singularities that accompany the step stones dig a potential ditch that stretches along the oscillation path. This ditch forms a geodesic path in which the particle can travel freely. These oscillations can be coupled to other potential wells or ditches. In this way the nucleus and the electrons are coupled in atoms.

28.2.7 Relational complexity indicators

The inner product of two Hilbert vectors is a measure of the relational complexity of the combination.

A Hilbert vector represents a linear combination of atomic Hilbert elements.

When all coefficients are equal, then the vector represents an assembly of atoms.
When the coefficients are not equal, then the vector represents a ***weighted assembly*** of atoms.

For two normalized vectors $|a\rangle$ and $|b\rangle$:

$\langle a|a\rangle = 1$ (1)

$\langle b|b\rangle = 1$ (2)

$\langle a|b\rangle = 0$ means $|a\rangle$ *and* $|b\rangle$ are not related. (3)

$\langle a|b\rangle \neq 0$ means $|a\rangle$ *and* $|b\rangle$ are related. (4)

$|\langle a|b\rangle| = 1$ means $|a\rangle$ *and* $|b\rangle$ are optimally related. (5)

28.2.8 Modular actions

Subsystems that have the ability to choose their activity can choose to organize their actions in a modular way.

As with static relational modularization the modular actions reduce complexity and for the decision maker it eases control.

28.2.9 Random design versus intelligent design

At lower levels of modularization nature designs modular structures in a stochastic way. This renders the modularization process rather slow. This way of modularization is called random design.

It takes a huge amount of progression steps in order to achieve a relatively complicated structure.
Still the complexity of that structure can be orders of magnitude less than the complexity of an equivalent monolith.

As soon as more intelligent subsystems arrive, then these systems can design and construct modular systems in a more intelligent way. They use resources efficiently.
This speeds the modularization process in an enormous way.

28.2.10 Probability distributions

Much in quantum physics has to do with the fact that the wave function has a direct relation to a probability density distribution and that the Fourier transform of this

probability density distribution describes a probability distribution of momenta that describe the motion of the considered object.
The HBM relates the wave function to a coherent discrete distribution of step stones that form a stochastic micro-path. During movements or quantum oscillations the micro-path stretches along the oscillation or movement path. This is done such that the above relation between locations and momenta is kept. With other words the mechanism that controls this, keeps Heisenberg's uncertainty principle intact.

The result of these measures is that under certain conditions the step stones can form interference patterns. This leads to the particle-wave duality of quantum scale objects.

29 Cosmology

Where quantum physics is ruled by the coupling equation, which is a special form of the differential continuity equation is cosmology ruled by the integral continuity equation.
At large scale also the sharp allocation function and its differentials plays a role. The differential can be interpreted as a metric.

29.1 The differential and integral continuity equations

Let us approach the balance equation from the integral version of the balance equation. Balance equation is another name for continuity equation.

We replace ψ by ρ, ψ_0 by ρ_0 and $\boldsymbol{\psi}$ by $\boldsymbol{\rho} = \rho_0 \boldsymbol{v}/c$.

$$\rho \stackrel{\text{def}}{=} \rho_0 + \boldsymbol{\rho} \tag{1}$$

When ρ_0 is interpreted as a charge density distribution, then the conservation of the corresponding charge[27] is given by the continuity equation:

Total change within V = flow into V + production inside V (2)

In formula this means:

$$\frac{d}{d\tau}\int_V \rho_0 \, dV = \oint_S \hat{\boldsymbol{n}} \rho_0 \frac{\boldsymbol{v}}{c} \, dS + \int_V s_0 \, dV \tag{3}$$

$$\int_V \nabla_0 \rho_0 \, dV = \int_V \langle \boldsymbol{\nabla}, \boldsymbol{\rho} \rangle \, dV + \int_V s_0 \, dV \tag{4}$$

[27] Also see Noether's laws: http://en.wikipedia.org/wiki/Noether%27s_theorem

The conversion from formula (2) to formula (3) uses the Gauss theorem[28].
Here $\hat{\boldsymbol{n}}$ is the normal vector pointing outward the surrounding surface *S*,
$\boldsymbol{v}(\tau, \boldsymbol{q})$ is the velocity at which the charge density $\rho_0(\tau, \boldsymbol{q})$ enters volume *V* and s_0 is the source density inside *V*.

In the above formula $\boldsymbol{\rho}$ stands for

$$\boldsymbol{\rho} = \rho_0 \boldsymbol{v}/c \tag{5}$$

It is the flux (flow per unit area and unit time) of ρ_0 .

The combination of $\rho_0(q)$ and $\boldsymbol{\rho}(q)$ is a quaternionic skew field $\rho(q)$ and can be seen as a probability density distribution (QPDD).

ρ is a function of q.

$$q \stackrel{\text{def}}{=} q_0 + \boldsymbol{q};\ q_0 = \tau \tag{6}$$

$\rho(q)\rho^*(q)$ can be seen as an overall probability density distribution of the presence of the carrier of the charge.
$\rho_0(q)$ is a charge density distribution.

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[28] http://en.wikipedia.org/wiki/Divergence_theorem

$\boldsymbol{\rho}(q)$ is the current density distribution.
This results in the law of charge conservation:

$$
\begin{aligned}
s_0(q) = \nabla_0\rho_0(q) & \\
& \mp \langle \boldsymbol{\nabla}, \left(\rho_0(q)\boldsymbol{v}(q) + \boldsymbol{\nabla} \times \boldsymbol{a}(q)\right)\rangle \\
= \nabla_0\rho_0(q) & \mp \langle \boldsymbol{\nabla}, \boldsymbol{\rho}(q) + \boldsymbol{A}(q)\rangle \\
= \nabla_0\rho_0(q) & \mp \langle \boldsymbol{v}(q), \boldsymbol{\nabla}\rho_0(q)\rangle \\
& \mp \langle \boldsymbol{\nabla}, \boldsymbol{v}(q)\rangle\, \rho_0(q) \\
& \mp \langle \boldsymbol{\nabla}, \boldsymbol{A}(q)\rangle
\end{aligned}
\tag{7}
$$

The blue colored $\pm$ indicates quaternionic sign selection through conjugation of the field $\rho(q)$.

The field $\boldsymbol{a}(q)$ is an arbitrary differentiable vector function.

$$\langle \boldsymbol{\nabla}, \boldsymbol{\nabla} \times \boldsymbol{a}(q)\rangle = 0 \tag{8}$$

$\boldsymbol{A}(q) \stackrel{\text{def}}{=} \boldsymbol{\nabla} \times \boldsymbol{a}(q)$ is always divergence free. In the following we will neglect $\boldsymbol{A}(q)$.

Equation (6) represents a balance equation for “charge” density. What this charge actually is, will be left in the middle. In fluid dynamics it can be one of the properties

of the carrier or it can represent the full ensemble of the properties of the carrier.

In the HBM it represents a balance equation for step stone density.

Up to this point the investigation only treats the real part of the full equation. The full continuity equation runs:

$$s(q) = \nabla\rho(q) = s_0(q) + \boldsymbol{s}(q) \tag{9}$$

$$\begin{aligned} = \; & \nabla_0\rho_0(q) \mp \langle \boldsymbol{\nabla}, \boldsymbol{\rho}(q) \rangle \pm \nabla_0 \boldsymbol{\rho}(\tau, \boldsymbol{q}) \\ & + \; \boldsymbol{\nabla}\rho_0(\tau, \boldsymbol{q}) \\ & \pm \left(\pm \boldsymbol{\nabla} \times \boldsymbol{\rho}(\tau, \boldsymbol{q}) \right) \end{aligned}$$

$$\begin{aligned} = \nabla_0\rho_0(\tau, \boldsymbol{q}) & \mp \langle \boldsymbol{v}(q), \boldsymbol{\nabla}\rho_0(q) \rangle \\ & \mp \langle \boldsymbol{\nabla}, \boldsymbol{v}\boldsymbol{q} \rangle \, \rho_0(q) \end{aligned}$$

$$\pm \nabla_0 \boldsymbol{v}(q) + \nabla_0\rho_0(q) + \; \boldsymbol{\nabla}\rho_0(q)$$

$$\begin{aligned} \pm \big(\pm (& \rho_0(q) \, \boldsymbol{\nabla} \times \boldsymbol{v}(q) - \boldsymbol{v}(q) \\ & \times \boldsymbol{\nabla}\rho_0(q) \big) \end{aligned}$$

After splitting into real and imaginary equations, this leads to:

(10)

$$s_0(q) = 2\nabla_0\rho_0(q) \mp \langle \boldsymbol{v}(q), \boldsymbol{\nabla}\rho_0(q)\rangle \mp \langle \boldsymbol{\nabla}, \boldsymbol{v}(q)\rangle\, \rho_0(q)$$

$$\boldsymbol{s}(q) = \pm\nabla_0 \boldsymbol{v}(q) \pm \boldsymbol{\nabla}\rho_0(q) \pm \Big(\pm\big(\rho_0(q)\, \boldsymbol{\nabla} \times \boldsymbol{v}(q) - \boldsymbol{v}(q) \times \boldsymbol{\nabla}\rho_0(q)\big)\Big) \tag{11}$$

The red sign selection indicates a change of handedness by changing the sign of one of the imaginary base vectors. Conjugation also causes a switch of handedness. It changes the sign of all three imaginary base vectors.

In its simplest form the full continuity equation runs:

$$s(q) = \nabla\rho(q) \tag{12}$$

Thus the full continuity equation specifies a quaternionic distribution s as a flat differential $\nabla\rho$.

When we go back to the integral balance equation, then holds for the imaginary parts:

(13)

$$\frac{d}{d\tau}\int_V \boldsymbol{\rho}\, dV = -\oint_S \hat{\boldsymbol{n}}\rho_0\, dS - \oint_S \hat{\boldsymbol{n}} \times \boldsymbol{\rho}\, dS + \int_V \boldsymbol{s}\, dV$$

$$\int_V \nabla_0\, \boldsymbol{\rho}\, dV = -\int_V \boldsymbol{\nabla}\rho_0\, dV - \int_V \boldsymbol{\nabla} \times \boldsymbol{\rho}\, dV + \int_V \boldsymbol{s}\, dV \tag{14}$$

29.2 The cosmological equations

The integral equations that describe cosmology are:

$$\frac{d}{d\tau}\int_V \rho\, dV + \oint_S \hat{\boldsymbol{n}}\rho\, dS = \int_V s\, dV \tag{1}$$

$$\int_V \nabla\, \rho\, dV = \int_V s\, dV \tag{2}$$

Here $\hat{\boldsymbol{n}}$ is the normal vector pointing outward the surrounding surface *S*, $\boldsymbol{v}(\tau, \boldsymbol{q})$ is the velocity at which the charge density $\rho_0(\tau, \boldsymbol{q})$ enters volume *V* and s_0 is the source density inside *V*. In the above formula ρ stands for

$$\rho = \rho_0 + \boldsymbol{\rho} = \rho_0 + \frac{\rho_0 \boldsymbol{v}}{c} \tag{3}$$

It is the flux (flow per unit of area and per unit of progression) of ρ_0 . τ stands for progression.

29.3 Space cavities

A static space cavity is characterized by:

$$\frac{d}{d\tau} \int_V \rho \, dV = 0 \tag{1}$$

All properties of this object depend on the surrounding surface.
These objects are known as black holes.

29.4 Inversion surfaces

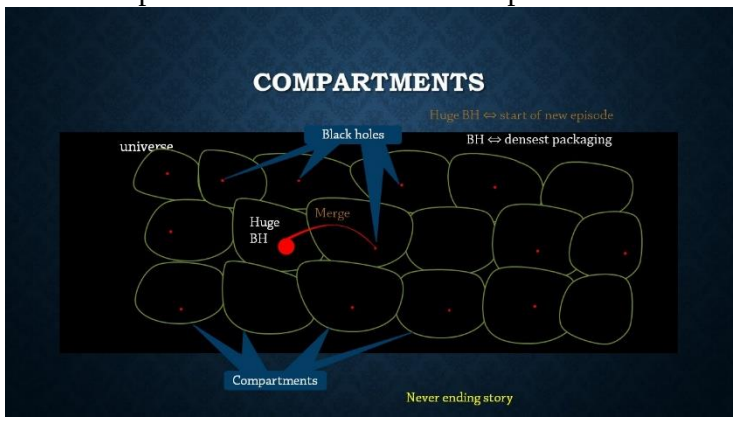
An inversion surface S is characterized by:

$$\oint_S \hat{\boldsymbol{n}} \rho \, dS = 0 \tag{1}$$

It is supposed that step stones are stopped, but that potentials and their constituting wave fronts can still pass this inversion surface.

29.5 Compartments

The inversion surfaces define compartments. Palestra is an affine space that is divided into compartments.



29.6 Cosmological history

The inversion surfaces divide universe into compartments. Think that these universe pockets contain matter that is on its way back to its natal state.

If there is enough matter in the pocket this state forms a black region. The rest of the pocket is cleared from its mass content.

Still the size of the pocket may increase. This corresponds to the expansion of the universe.

Inside the pocket the holographic principle governs. The black region represents the densest packaging mode of entropy.

The pockets may merge. Thus finally a very large part of the universe may return to its birth state, which is a state of densest packaging of entropy.

Then the resulting mass which is positioned at a huge distance will enforce a uniform attraction. This uniform attraction will install an isotropic extension of the central package.

This will disturb the densest packaging quality of that package.

The motor behind this is formed by the combination of the attraction through distant massive particles, which installs an isotropic expansion and the influence of the small scale random localization which is present even in the state of densest packaging.

This describes an eternal process that takes place in and between the pockets of an affine-like space.

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