Cracks of fundamental quantum physics

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Abstract

The fundaments of quantum physics are still not well established. This paper tries to find the cracks in these fundaments and suggests repair procedures. This leads to unconventional solutions and a new model of physics. As part of this enterprise an underpinning of the existence of strands is provided. Another innovation is the derivation of a curvature field from the superposition of all other fields. The most revolutionary introduction is the representation of dynamics by a sequence of separable Hilbert spaces.

History

In its first years the development of quantum physics occurred violently. As a consequence some cracks sneaked into the fundaments of this branch of physics. A careful investigation brings these cracks to the foreground. The endeavor to repair these cracks delivers remarkable results.

In the early days of quantum physics much attention was given to equations of motion that were corrections of classical equations of motion. The Schrödinger approach was one and the Heisenberg approach was another. Schrödinger used a picture in which the state of a particle changes with time. Heisenberg uses a picture in which the operators change with time. For the observables this difference makes no difference. Later Garret Birkhoff, John von Neumann and Constantin Piron found a more solid foundation that was based on quantum logic. They showed that the set of propositions of this logic is isomorphic with the set of closed subspaces of an infinite dimensional separable Hilbert space, whose inner product is defined with the numbers taken from a division ring. The ring can be the real numbers, the complex numbers or the quaternions. Since then many physicists do their quantum physics in the realm of a Hilbert space.

Cracks in the fundaments

Fist scratches

These physicists quickly encountered the obstinate character of the separable Hilbert space. Its normal operators have countable eigenspaces. This can still correspond to a dense coverage of the corresponding hyper complex number space. However, this space is no continuum. Thus, functions defined using these eigenspaces as parameter domains cannot be differentiated. In order to cope with this defect, most physicists resorted to the corresponding rigged Hilbert space, but in doing so they neglect that in this way the relation with quantum logic gets lost.

Severe defects

Further, it appears that the separable Hilbert space cannot represent physical fields and cannot represent dynamics. This is a severe drawback and it looks as if the switch to the rigged Hilbert space becomes mandatory. For example quantum field theory represents fields as operators that reside in this rigged Hilbert space.

Back to the future

On the other hand there are more and more signals that nature is fundamentally granular and rigged Hilbert spaces do not provide that feature. This guides backwards to the separable Hilbert space. But in that case we must learn to live with its granularity. In addition we must find other ways to represent fields.

Dynamic way out

The rigged Hilbert space gave similar problems with representing dynamics as the separable Hilbert space does. There is no place for time as an eigenvalue of an operator neither in separable Hilbert space nor in rigged Hilbert space. For that reason, it is better to accept that the separable Hilbert space can only represent a static status quo.

Coping with granularity

A solution must be found for the fact that GPS-like normal operators in separable Hilbert space possess granular eigenspaces. It means that it is impossible to define an operator that acts like a global positioning system (GPS), which is required in the positioning of field values or when we want to relate Hilbert vectors with position.

Underpinning for strands

The separable Hilbert space can provide a GPS-like operator that offers a dense coordinate system as its eigenspace. An eigenspace consisting from all rational quaternionic numbers would be countable and thus it can be an eigenspace of a normal operator.

However this eigenspace does not support differentiation and is not granular. In nature the space of the positions is granular and the size of the granules is of the order of the Planck length, which is $1.6 \cdot 10^{-35}$ m. The densely packed granules of the granular GPS-like operator would immediately generate unnatural preferred directions.

This fact holds for any multidimensional subset of eigenvalues.

Background coordinates

A background coordinate system exists in rigged Hilbert space, but when we insist on granularity of the GPS-like coordinates, it cannot be directly used in separable Hilbert space in order to locate Hilbert vectors in a regular way. As signaled before, this will introduce anomalies. So, we must find an indirect way. This is delivered by the strand operator, which resides in separable Hilbert space and has an equivalent in the rigged Hilbert space. There it can be coupled to the background coordinate system. The strand operator does not possess multidimensional sets of eigenvalues. Thus, it avoids the mentioned problems in separable Hilbert space.

Strand operator

It is possible to define a normal operator in separable Hilbert space whose eigenspace consists out of a set of chains that are put together from granules. In the chain the granules are ordered. In each chain one granule is exceptional. We call it the **current granule**. The part of the chain that ends just before the current granule is called the past sub-chain. The part that starts just after the current granule is the future sub-chain. Via the background coordinate system that is delivered by the rigged Hilbert space each granule gets its own position. That value becomes the eigenvalue of the Hilbert vector that corresponds with the granule. In this way the chain defines a trail of Hilbert vectors. For the model, the direct neighborhood of the current granule is the most relevant part of the chain.

Strand space

The operator has an outer horizon. Outside this horizon its eigenspace does not contain chains. It might also have inner horizons such that inside these inner horizons no chains exist.

The chains are closed or they start and end at a horizon. They may also reflect tangentially against a horizon. These chains have much in common with the strands in Schiller's strand model. However, they are not exactly the same.

At field excitations the chains may be generated or annihilated. This occurs for example in field configurations that are locally invariant under Fourier transformation, such as linear and spherical harmonics.

Fields

Fields do not fit inside a separable Hilbert space. Any field would cover the whole Hilbert space. Every Hilbert vector would touch a value of the field. Which value is touched, depends on the functionality of this vector. When the vector is one of the eigenvectors of a normal operator and when the field can be expressed as a function of the eigenvalues of this operator, then the field value would correspond with the eigenvalue that corresponds to eigenvector. In that case, the considered field value will be connected to the considered vector.

Function of the field

The function of the physical fields is to take care of minimizing changes during dynamical steps. This function becomes evident when dynamics is implemented. Fields keep the shape of the chains of the strand operator smooth.

Basic field constituent

A probability amplitude distribution that is attached to the current granule takes care of the fact that the chain in the neighborhood of the current granule stays sufficiently smooth. This becomes important when dynamics is implemented because with each dynamic step the current granule either stays at its current position or it moves one place ahead in the chain.

The squared modulus of the probability amplitude distribution is a probability density distribution. It determines the probability of the position of the current granule. The probability is large when the position is close to the position of the previous current granule.

Fields influence the strand

The rest of the chain may be influenced by the probability distributions of the current granules of other chains. Taken over a sequence of dynamic steps, the chain appears to fluctuate. The fluctuation determines the probability distribution and vice versa the dynamic changes of the probability density distribution determine the fluctuations of the chains. This relation is instantaneous. There is no causal relation.

If the chains would be observable, then the probability distribution could be determined by averaging the fluctuations over some period. However, neither the chains, nor the probability amplitude function are directly observable items. Only their effects become observable.

Particles

Depending on its type, an elementary particle relates to one, two or three of these chains. In this way the current granules of these chains are related to the current section of the path of the particle.

Curvature, torsion and chirality

In contrast to torsion, curvature relates to mass. For example, according to strand model, the chain that represents a massless photon has a helix shape. The chains that represent the massive W bosons have the shape of an overhand knot. Since this knot shows chirality, it possesses electric charge. The chains that represent the massive Z bosons have the shape of a figure eight knot. Because the figure eight knot features no handedness, it does not possess electric charge. In a similar way Schiller [2] attributes properties to all elementary particles.

Extended Hilbert space

The addition of probability amplitude distributions to the current granules extends the separable Hilbert space to a new construct. For that reason we call this construct an extended separable Hilbert space.

Extended quantum logic

Via the relation between the separable Hilbert space and traditional quantum logic we can extend quantum logic to an extended quantum logic that includes physical fields in a similar way as the extended Hilbert space model does.

Covering field

The probability amplitude distribution that is connected to the current granule is a basic field constituent. The superposition of all these basic constituents forms a covering field. The configuration of the covering field depends on the configuration of the elementary particles. When the configuration of chains changes, then the configuration of particles changes and the covering field changes accordingly.

Curvature field

According to Helmholtz theorem, the static covering field decomposes into a rotation free part and one or two divergence free parts. The local decomposition into a one dimensional longitudinal part and a transverse part defines a local curvature. This curvature can be used to define a derived field. We will call this the curvature field. It has all aspects of the gravitation field. When split back into curvature fields that are private to the particles the private curvature field can be used to attach the property "mass" to the corresponding particle.

Canonical coordinates

We start with the situation in which we can select ideal coordinates. What that means will become clear soon.

Ideal coordinates

The inner product of the Hilbert space can be used to relate two orthogonal bases that are each-other's canonical conjugate. In a quaternionic Hilbert space this is not a straightforward procedure. Luckier wise, the quaternionic number space can be divided into a series of complex number spaces. We just chose one imaginary direction and do as if we are in complex Hilbert space. However, this singles out that particular direction and we must have a good reason for that. We may choose the direction in which the local longitudinal direction of the covering field runs. This may give problems when this direction changes with position. For the moment we assume that we have selected a coordinate system for which the longitudinal field direction runs along a straight line. We do not bother about granularity, because at this phase it does not harm us. So we pick the eigenspace of a normal GPS-like operator Q as our coordinate system. It has an equivalent GPS-like coordinate operator in rigged Hilbert space. As said before the operator is selected such that the longitudinal direction of the field runs along one of the imaginary base vectors of the eigenspace. The set of eigenvectors $\{|q>\}$ of operator Q forms an inner product with another normal operator P which is the canonical conjugate of Q. The eigenvector $|q>$ corresponds to an eigenvalue q and similarly the eigenvector $|p>$ of P corresponds to an eigenvalue p. The inner products are now given by:

$$< p|q > = \exp(\mathbf{i}\hbar qp) \qquad (1)$$

The constant h in $\hbar = 2\pi h$ is Planck's constant. The imaginary 3D base vector **i** of the quaternionic number space is the imaginary base number of the complex number space.

This procedure can be performed for the two operators and three mutually perpendicular imaginary base vectors. We have defined the procedure for the operators P and Q that reside in separable Hilbert space, but with respect to its application to Fourier transforms, it makes more sense for the equivalent operators in rigged Hilbert space.

Fourier transform

It can easily be seen that the specified inner product also defines a complex Fourier transform. And taking all three dimensions it defines the imaginary part of a quaternionic Fourier transform.

$$< q|f > = < f|q >^* = f^*(q) = \sum_p (< q|p > \cdot < p|f >) \qquad (2)$$

And reversely:

(3)

$$< p|f > = \sum_{q} (< p|q > \cdot < q|f >)$$

It must be reckoned that these are discrete transforms. Here a **Hilbert function**

$$f(q) = < f|q > \tag{4}$$

is transformed into its Fourier partner.

Use of the Fourier transform

In separable Hilbert space, Hilbert functions are sampled functions and are constructed from the eigenvectors and eigenvalues of a normal operator and a selected Hilbert vector. See formula (4).

The discrete transform and the Hilbert functions do not have many usages. In practice the Fourier transform is applied to Hilbert fields rather than to Hilbert functions.

The Fourier transform of a quaternionic field must be performed with a quaternionic Fourier transform that acts in a continuous number space [3].

The Fourier transformation of a private field of a particle does two things. It shifts from a GPS-like coordinate system to its canonical conjugate GMS-like coordinate system. Apart from that it transforms the private field from a quantum cloud into a wave package. This new probability distribution tells about momentum rather than about position.

Actual coordinates

In practice the ideal conditions are seldom valid and if they are valid they are only valid locally. It means that the inner product (1) has only local validity and the same holds for the Fourier transforms that are specified with the aid of that inner product. In fact the environment gets curved. Only a coordinate transformation can bring us back to the ideal situation. This is a purely mathematical activity. It does not affect physical reality. So if we know how to perform this coordinate transformation then physics becomes trivial. This is the reason why particles move along geodesics.

The presented picture supposes that nowhere the field excitations are so violently that it becomes impossible to define a local curvature. With this restriction, the required coordinate transformation stays possible.

Distributions and fields

The concepts that have been introduced so far invite the introduction of Hilbert distributions and Hilbert fields.

Hilbert distributions

Hilbert distributions are sets of Hilbert vectors, which each correspond to the current granule of a chain. Thus, these vectors are eigenvectors of the strand operator. An **elementary Hilbert distribution** is a set of Hilbert vectors that belong to an elementary particle.

Hilbert field

A Hilbert field is a blurred Hilbert distribution. The blurs are the probability amplitude distributions that are attached to the corresponding current granules.

A **private Hilbert field** is a Hilbert field that belongs to an elementary Hilbert distribution. However, if a complicated particle consists of a set of elementary particles, then we consider the superposition of the private fields of the elementary particles as the private field of the complicated particle.

The covering field is the superposition of all private fields.

Optics and quantum physics

If all probability amplitude distributions would be similar, then the Hilbert field can be considered as the convolution of this probability amplitude distribution and a distribution of Dirac delta functions that correspond to the Hilbert distribution. This picture resembles ray optics and if we take the Fourier transform then it resembles Fourier optics. This is the reason that wave mechanics has so much similarity with optics. The Optical Transfer Function characterizes the information transfer capability of an imaging system. In similar way the Fourier transform of the probability amplitude distribution characterizes the information transfer capability of a physical system.

Nothing is said yet about detecting the information that is carried by the particles. That will be treated later.

Dynamics

The extended separable Hilbert space model can only represent a **static status quo**. By using this ingredient, dynamics can be implemented by a model that consists of an ordered sequence of such extended Hilbert spaces. It corresponds to an equivalent sequence of extended quantum logics.

Spacetime

This procedure introduces a new parameter that acts as a global progression step counter. This parameter must not be confused with our common notion of time, which only has local validity. The dynamic model implies that space is not the only granular quantity. It also means that progression occurs in discrete steps. Further, it indicates that against general acceptance, fundamentally, space and progression have little to do with each other. With other words, no support exists for a fundamental physical spacetime quantity.

That does not say that no relation between the fundamental space step and the fundamental time step can exist. The Minkowski signature is a clear prove of such relation. Its explanation must be sought in what happens during an infinitesimal progression step. This subject will not be treated here, but see [3].

When the smallest possible space step $l_{Pl} = \sqrt{\hbar G/c^3}$ and the smallest possible coordinate time step $t_{Pl} = \sqrt{\hbar G/c^5}$ are put into the Minkowski signature,

$$\Delta t^2 = \Delta\tau^2 - \Delta q^2/c^2 \tag{5}$$

then the corresponding spacetime step $\Delta\tau$ is zero.

The number of Planck time steps equals the number of global progression steps. The number of Planck length steps must always be equal to or lower than the number of Planck time steps. The photon never takes a non-zero spacetime step. The number of its space steps always equals the number of its time steps.

Any particle that does not travel with light speed skips some of its space steps. Any particle can take a space step in a direction that differs from the direction of a previous step.

Strand model

The main difference between the Hilbert space approach that is taken here and Schiller's approach lays in the interpretation of the source of the observable data. The principle fundamental postulate of Schiller's strand model is that the crossing switches of strands deliver the observable data. In the Hilbert approach the cloud of quanta that corresponds with the moving and rotating probability amplitude distributions that are connected to the current granules carry the observable data. There must be no difference between the results of the two models.

Further, Schiller's strand model derives fields from strand tangles. In the Hilbert approach the shape and the fluctuation of the chains are controlled by fields. As indicated before there is no difference between the two pictures because the relation is instantaneous and involves no causality.

In both pictures the described concepts form the basis of a consistent model. This model delivers the proper equations of movement. [2], [3]. The reason of this conformance lays in the similarity of the basic field constituents.

Information detection

All information that is transmitted by nature is carried by clouds of information carrying quanta. The clouds themselves carry secondary information in their shape and their movement characteristics. It looks as if all quanta are generated by a series of Poisson processes. These facts become apparent when observations or measurements are done at very low dose rates [3]. The shape of the cloud is set by the corresponding probability amplitude distribution.

Discussion

This model of physical reality does not contain continuous waves. It does not contain singularities. Nor does it contain infinities. The only infinity it uses is the infinity of the dimension of the separable Hilbert space.

The model is fundamentally granular. The only continuities that the extended Hilbert space uses are the continuity of the background coordinate system that it borrows from its rigged partner and the continuity of the shapes of the probability amplitude distributions.

Schiller's strand model takes the conclusions still further. He claims that this theory fully explains the standard model and that no further particles than those specified by the standard model exist.

Apart from the difference with respect to the main postulate of strand model, an important difference exists between the approach presented here and Schiller's strand model. Schiller presents the gravitation field as a separate field that is mainly determined by distant fluctuations of tangle tails. In this paper, the gravitation field is treated as a derived field. It has long range effects due to the fact that its charges (the curvature values) do not get compensated by opposite charges as happens with electric charges. Prove is given by the existence of inertia, which can only be explained by analyzing the influence of the universe of particles on a local particle [3], [4]. Locally this influence causes an enormous potential, which according to Sciama can be characterized by the gravitational constant G. Uniform movement of a particle does not raise other field activity than a field reconfiguration, but any acceleration of the particle goes together with an extra vector field [4].

The rigged partner **Ħ** of a separable Hilbert space **Ң** is not a separable Hilbert space, but a Gelfand triplet. It is an ordered set $(\Phi,$ Ң$, \Phi^x)$, where **Ң** is the Hilbert space used to generate Φ and Φ^x. The eigenspaces of normal operators in a Gelfand triplet need not be countable. They can be continuous spaces such as the full set of quaternions. The name of Hilbert is misused to identify the Gelfand triplet as a rigged Hilbert space. This paper uses the Gelfand triplet **Ħ** in order to provide a background GPS system and to couple the equivalent of the separate Hilbert space strand operator to the corresponding GPS operator. Both the equivalent strand operator and the GPS operator reside in the rigged Hilbert space Ħ. In this way the granules of the chains that reside in separable Hilbert space get their position. Another use of the background GPS operator is the coupling of field values to a position value. For that purpose the field values must be attached to the corresponding eigenvectors in rigged Hilbert space Ħ.

Open issues

Not treated here are the equations of motion. They are intimately related to what happens during the infinitesimal progression steps that link the members of the sequence of extended Hilbert spaces.

They are also closely related to the dynamic equations that treat Hilbert fields and as can be expected show great resemblance with the Maxwell equations.

One thing can already be stated:

All equations of motion are in fact continuity equations that treat the local information generation, annihilation and transfer.

Total change within V = flow into V + production inside V (5)

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