On the origin of physical dynamics and special relativity.

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Abstract

The origin of physical dynamics and the reason of existence of special relativity are explored. This endeavour is started by analysing the logic of nature. Next, only mathematics is used in order to explore the dynamics of this model of physical reality.

The model that is described here annihilates the old reality and creates a new reality at each dynamic step. Hilbert space cannot treat dynamics. It contains nothing that supports dynamics. In the contrary, dynamics manages the Hilbert spaces. Like traditional quantum logic, Hilbert space cannot treat physical fields. By embedding the separable Hilbert space in a rigged Hilbert space, it can house fields by representing them as blurred sets of Hilbert vectors. The field is the convolution of the blur with a set of Dirac delta functions that represent Hilbert vectors. When the blur is differentiable, then the field is differentiable as well. The field values are attached to the Hilbert vectors. In this way traditional quantum logic can be expanded, such that it also treats fields. This extended quantum logic still cannot handle dynamics. The logic only describes a static status quo. Dynamics let nature step from one status quo to the next. It does that by letting nature transform from configuration space to Fourier space. There the fields control the difference between the past and the future status quo. The Fourier transform converts the rather complicated differentiation into a simple multiplication and since the multiplication factors are close to unity, this comes down to still simpler addition. After the confrontation in Fourier space, nature returns back to configuration space. Feynman's path integral approach exploits this fact. The up and down Fourier transforms reshuffle the Hilbert vectors. All Hilbert vectors are affected. The Hilbert vectors represent virtual or actual quanta and present themselves as shot noise.

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Logic system

When reasoning about physical reality, it is safe to follow the rules of classical logic. If one starts with a true statement and these rules are followed then the path of reasoning stays with truth. Classical logic is based on about 26 axioms. A significant part of these axioms defines the structure of the logic as a half-ordered set and some other axioms expand this to define the set as a lattice. The other axioms have more to do with the rules that must be followed in order to reason logically. May be it is a good starting point to use logic itself as a fundament of physics.

In the first decades of the last century it was discovered that nature itself cheats with classical logic. Numerous observations of the behaviour of small particles revealed that the interrelations between these observations are in conflict with classical logic. Birkhoff and von Neumann interpreted this conflict and came to the conclusion that nature obeys its own kind of logic. They named this logic quantum logic.

Only one axiom of classical logic was violated. This axiom is known as the modular law. The axiom that nature uses is weaker. It is known as the weak modular law.

The structure of classical logic can simply be represented by Venn diagrams. As is common in such cases the relaxation of a law leads easily to anarchy or at least a far more complex structure of what the set of laws define.

The last happens also in this case. The Venn diagram representation no longer fits. Instead a complicated mathematical construct replaces this simple representation. Birkhoff and von Neumann found that the set of propositions in a quantum logical system has the same lattice structure as the set of closed subspaces of an infinite dimensional separable Hilbert space.

Hilbert spaces

Hilbert spaces feature an inner product between its vectors. This inner product can be defined using numbers selected from one of three division rings. These are the real numbers, the complex numbers or the quaternions. Higher dimensional hyper complex numbers, such as the octonions or double complex numbers such as the bi-quaternions do not fit.

Operators

In Hilbert space linear operators can be defined that may have eigenvalues. The eigenvalues of operators appear to represent observable values of properties of physical items. In this way the Hilbert space relates to physics.

It is common to take the eigenvalues of these operators from the same division ring as is used to define the inner product, but this restriction is too strong. It is conceivable to use higher dimensional hyper complex numbers as eigenvalues.

The arithmetic capabilities of hyper complex numbers deteriorate with the increase of their dimension. However, the 2^n-ons behave like 2^m-ons in their lower m dimensions. If two 2^n-ons approach each other, then their mutual arithmetic behaviour also becomes better and as a consequence they can be treated in this condition as lower dimension 2^m-ons.

The fact that the Hilbert space is separable has as consequence that the eigenspaces of operators are always countable, even when they are infinite. The cardinality of the eigenspaces equals the cardinality of the rational numbers, which is equal to the cardinality of the natural numbers. It means that all eigenvalues can be labelled by a natural number. The eigenvalues do not form a closed set. The limits of convergent series of eigenvalues need not be member of the eigenspace.

Physical items

A subset of the quantum logical propositions concerns the static properties of physical items. A complete hierarchy of propositions represents a single item, where the proposition that represents the item is at the top of this hierarchy. That proposition corresponds to a Hilbert subspace. This means that the subspace also represents the physical item.

If the properties of the physical item change, then this means also a change of the hierarchy of propositions that belong to representation of the item. Thus, the configuration of the subspace that represents a physical item may change with time.

States

Most quantum physicists use a state in order to characterize a physical item. A state can be represented by a wave function or by a probability density operator. The wave function can be interpreted as probability amplitude.

A state is not a comprehensive representation of a physical item, because depending on circumstances the state takes another shape. For example, after a measurement of position the state is a function of position and after a measurement of momentum the state is a function of momentum.

Fields

Quantum logic and its representative the Hilbert space do not treat physical fields and they do not treat dynamics. Physical fields, such as the gravitation field, the electrostatic field or the magnetostatic field, cover the whole Hilbert space rather than a single subspace. Their role differs considerably from the role of physical items.

It is possible to construct a function by taking the inner product of a given Hilbert vector with the eigenvectors of a compact normal operator as function values and the eigenvalues that belong to these eigenvectors as the corresponding function parameter.

$\ell^2$is isomorphic with a separable Hilbert space and consists of integrable and differentiable functions, but, as with any separable Hilbert space, the eigenvalues of operators in ℓ^2 do not form a closed set.

The operator is selected such that its eigenvalues are everywhere dense in the division ring that is used to define the inner product. In this way the operator acts as a kind of GPS for the Hilbert space. Therefore the operator will be indicated as *coordinate operator*.

The count-ability has as consequence that the eigenspaces cannot be used to construct continuous functions in the way as described above. I will use the name *Hilbert function* for this type of nearly differentiable functions.

Now take another operator that shares a subset of the eigenvectors of the coordinate operator. The eigenvalues of this new operator may be hyper complex 2^n-on numbers with arbitrary n such that addition between these numbers is still well defined. This set of shared eigenvectors forms a distribution that will get the name *Hilbert distribution*.

Next construct a *Hilbert field* on the basis of a blurred Hilbert distribution by taking the convolution of a Hilbert distribution and a differential function that acts as the blur. The Hilbert vectors themselves can be treated as Dirac delta functions. In fact, this convolution is impossible in the realm of a separable Hilbert space. In order to perform the convolution the Hilbert space must be packed in a rigged Hilbert space. When the function has sufficient extent, then the Hilbert field becomes everywhere differentiable in the rigged Hilbert space. The rigged Hilbert space is NOT isomorphic with traditional quantum logic. For that reason, as a final step, the values of the field are attached to the Hilbert vectors of the separable Hilbert space.

For a given field the blur is the same for all Hilbert vectors concerned and as a consequence the blur is typical for the field. Several fields may share the same Hilbert vectors.

Special kinds of blurs represent probability amplitudes. These probability amplitudes also represent probability density distributions. The density is the square of the modulus of the amplitude. Since wave functions are probability amplitudes we have now created some tools that can support quantum physics.

The correspondence of the blur with optical blur is responsible for the great similarity between wave mechanics and optics.

Like the Hilbert space, Hilbert functions, Hilbert distributions and Hilbert fields are static constructs.

Split

Applying Helmholtz decomposition theorem to the Hilbert fields splits these fields into a rotation free part and a divergence free part. This split has a validity that is restricted to the region where the characteristics of the field are sufficiently uniform. The reason for this restriction is that the direction in which the field is rotation free may vary with position.

The Helmholtz split corresponds with a similar split of the quaternionic Fourier transform. It also corresponds with a similar split of Dirac's multidimensional delta function. This is due to the fact that the Fourier transform converts differentiation into simple multiplication. In fact the split may go further, because the divergence free part is two-dimensional.

Field dynamics

In this way an equivalent of the Maxwell equations for static fields rolls out of the exploit of the Helmholtz split. Balance equations reveal what happens when dynamics interconnects the static field parts.

Another indication is delivered by the analysis of inertia. Inertia is caused by the cooperation of the influences that are exerted by the community of the universe of physical items. The distant members of this community represents a solid uniform background influence that creates locally an enormous scalar potential and when the local item moves with uniform speed it goes together with a strong vector potential.

An acceleration of the local item goes together with an extra field that counteracts the acceleration. This last effect represents the action of inertia. All these features are a consequence of the existence of blurred sets of Hilbert vectors that represent physical fields.

Besides linear inertia rotational inertia exists as well.

The expression "goes together with" indicates simultaneous existence. There is no causal relation.

Field interpretation

The fields play an important role and have several functions/interpretations:

- From the analysis of inertia you can derive that they represent the sticky resistance of the community of propositions/physical-items against unordered change. A uniform movement is still considered as a well ordered change. Acceleration is considered as unordered change and goes together with field activity.
- Fields are constituted of blurred sets of Hilbert vectors. With other words Hilbert fields are blurred Hilbert distributions. The blur is typical for the field and renders the field differentiable. On the other hand the blur can be interpreted as probability amplitude. (Wave functions are probability amplitudes)
- Fields can be interpreted as the storage place of the conditions of future, present and past Hilbert spaces or equivalently as the storage place of the

conditions of future, present and past versions of quantum logic systems. The Hilbert spaces and the quantum logics describe a static status quo.
- Fields can be interpreted as the housing of annihilation and creation operators that act on actual or virtual particles.
- The probalistic nature of the fields invites their interpretation as clouds of quanta. These quanta represent potential realizations of Hilbert vectors that on their turn represent particles in past, present or future versions of traditional quantum logic.

Dynamics

Dynamics means that nature steps from one static status quo to the next static status quo. It steps from a future static status quo to the present static status quo and simultaneously from the present to the past static status quo. Each version of static status quo was, is or will be represented by a Hilbert space and by the static versions of the fields that exist with the static status quo.

This means that traditional quantum logic can be expanded first by interpreting fields as the storage place of the conditions of future, present and past Hilbert spaces or equivalently as the storage place of the conditions of future, present and past versions of (traditional) quantum logic systems.

Traditional quantum logic and the corresponding Hilbert space describe a static status quo. Thus the *extended quantum logic* consists of an ordered set of consecutive traditional quantum logics, whose succession is regulated by the fields.

Next this extended quantum logic can be expanded to a *dynamic quantum logic* by including axioms that specify what happens during the step from a given static status quo to the next. After the step the previous Hilbert space is replaced by the next version and the configurations of the static fields have changed as well.

Analysing the step

Nature appears to use a trick in order to implement that step. It leaves the current version of configuration space and enters Fourier space. In Fourier space the fields and the current condition of the physical items get confronted.

The complicated differentiation that would have to be processed in configuration space becomes a much simpler multiplication in Fourier space. Since the step is infinitesimal the action is governed by a multiplication with factors that are close to unity. That means that the multiplication comes down to a rather simple addition. Thus the confrontation is implemented via additions.

After the simplified processing in Fourier space, nature returns back to configuration space.

Fourier analysis

When the performance of a chain of linearly operating appliances is analysed, then the best strategy is to take the Fourier transform of each component in the form of a frequency characteristic and multiply all these characteristics in order to obtain the frequency characteristic of the chain. Next the frequency content of the input to the chain is multiplied with the frequency characteristic of the chain in order to obtain the frequency content of the output.

In optics the frequency characteristic is called optical transfer function (OTF). There exist great similarity between this procedure and the procedure described above for quantum physics. In optics as well as in wave mechanics the spatial variance in lateral direction of the actors must be accounted for. In wave mechanics a continuously varying refraction determines the characteristics of the chain. In glass lens optics the chain elements are discrete. In electron optics the chain elements are continuous.

Probabilities

The ground state of a harmonic oscillator represents a Gaussian distribution. The Hermite functions, which are describing harmonic oscillations, are invariant under Fourier transformation and contain a Gaussian factor.

Convolution with a spherical symmetric Gaussian probability distribution means that at the distance much larger than the spread σ the blur function decreases as $1/r$. This is the form of the potential function of a single charge that characterizes both the gravity and the EM field. Bertrand's theorem states that this potential form is one of two that produce stable, closed orbits.

It appears that in general the solutions of the Laplace equations are invariant under Fourier transformation. For example spherical harmonics follows this attitude. Also these functions contain a Gaussian probability density as a factor.

Coherent states are invariant under annihilation and creation operators. They are characterized by a blur in the form of a Poissonian distribution. Everybody who is familiar with shot noise knows that shot noise is characterized by a Poissonian probability distribution.

These are a few of the indications that fields as well as solutions of the Laplace equation can be interpreted as being probability density distributions. Probability of what? Hilbert fields are blurred Hilbert distributions. The blurs and as a consequence the fields are not hanging as a lose substance in the Hilbert field.

The blurs are spread over the Hilbert vectors. . Each Hilbert vector in the domain of a blur touches this blur and caries the local value of that blur. At each Hilbert vector the value of a field corresponds to a value of the corresponding probability amplitude. This probability amplitude constitutes a probability density. The density is the square of the modulus of the amplitude.

Clouds of quanta

In this sense the Hilbert vectors can be interpreted as potential (=virtual) or actual quanta and the field can be interpreted as a quantum cloud. The probability density distribution specifies for these quanta the chance that they are realizations of past, present or future actual quanta.

When nature steps from configuration space to Fourier space it changes from a position coordinate base to a momentum base. In this way all Hilbert vectors are affected. They are reshuffled. It means that the quantum cloud gets a different significance. In Fourier space the cloud is confronted with the actors. That means that the distribution slightly changes. As indicated before the interaction consists of simple, mostly small additions. After this confrontation nature steps back to configuration space. Thus, the base changes back from a momentum base to a position coordinate base. Again all Hilbert vectors are effectively reshuffled. With the overall step many of the Hilbert vectors receive different field values. The quantum cloud changed accordingly.

Quantum perception

If you work with image intensifiers like star light night vision devices or X-ray image intensifiers, like I did in part of my career, then you see the image built up out of separate quanta. It gives you a feel of how the quantization works.

What you see then is the effect of a multitude of attenuated Poisson processes that can be seen as the combination of shot noise generating Poisson processes that combine with zero or more attenuating binomial processes into generalized Poisson processes that have lower quantum generation efficiency than the original Poisson processes. For large numbers of quanta, the Poisson distribution of the quanta approaches a normal (=Gaussian) distribution.

The blur also represents a binomial process. It spreads the quanta over a larger region and thus lowers the local density. This affects the signal to noise ratio of the spatial information transfer.

The detective quantum efficiency (DQE) of the detection channel is a significant quality measure in linear intensified imaging. As indicated earlier, there exists much similarity between optics and wave mechanics.

Equations of movement

The combination of the analysis of inertia and the Frenet-Serret formulas for a curved naturally re-parameterized path, which is a geodesic and which leads to the geodesic equation, deliver the equations of motion that describe the local dynamic behaviour of nature in the form of a geodesic equation.

Another way of getting a similar result is following a potential path of a virtual or actual particle (one member of the cloud) and analyse what happens to that particle during an infinitesimal step.

Special relativity

This analysis also reveals the origin of special relativity. When the name *progression parameter* is given to the counter that enumerates the dynamical steps, then the corresponding *action step* Δs, the *space step* Δq and the *coordinate time step* Δt have a triangle relation. The *spacetime step* $\Delta\sigma$, the space step Δq and the coordinate time step Δt form a right angled triangle with Δt at the hypotenuse.

This leads to the formula $\Delta t^2 = \Delta\sigma^2 + \Delta q^2/c^2$, or better $\Delta\sigma^2 = \Delta t^2 - \Delta q^2/c$. The formula specifies the *Minkowski signature* of spacetime. It is the fundament or as you like the origin of special relativity. $\Delta\sigma$ is the spacetime step, which is proportional to the *proper time step* $\Delta\tau$. The spacetime step is directly influenced by the action that controls the movement. The spacetime step, the action step and the proper time step are all proportional to each other. The step of the progression parameter also fits in this row.

References

Details can be found in "On the origin of dynamics".

An on-going project that explores this subject prepares the next version of the paper mentioned before.

Details about the geodesic equation are explained in : Wikipedia

The path integral approach is treated in:

http://en.wikipedia.org/wiki/Path_integral_formulation#Quantum_action_principle.

Another enlightening description is given in http://arxiv.org/PS_cache/hep-th/pdf/0207/0207276v1.pdf

Potentials that produce closed orbits are treated in Bertrand's theorem.

The path of a particle is a curved trail, which is described by the Frenet-Serret formulas.

Sciama's analysis of inertia is described in "On the origin of inertia".