Last changed: 10/30/2010 6:07 PM

A bare bone vision on the origin of physical dynamics

Sciama's approach

I like to guide your attention to the work of Denis Sciama who in his article "On the origin of inertia" (http://www.adsabs.harvard.edu/abs/1953MNRAS.113...34S) has put a very interesting view not only on the origin of inertia, but also on the origin of gravity. His approach includes the influence of the whole of the universe. He starts by simplifying the problem to its bones. He assumes that the most distant items in universe together constitute the largest influence on the chosen subject. The increase of the number of contributing items with distance grows faster than the decrease of the influence of the separate items with that distance. Every variance in this background averages out. So this background acts as a uniform solid body. Sciama uses this in the computation of the Newton potential at the location of a chosen subject. The background uniformity is used in the form of a constant "charge" density. Charge is used here in the same sense as it is used in Noether's theorems. In general, it is not electric charge. Sciama's approach fits several types of fields.

The total potential at the location of the influenced subject is

$$\Phi = -\int_V \frac{\rho}{\boldsymbol{r}} dV = -\rho \int_V \frac{dV}{\boldsymbol{r}} \tag{1}$$

Next Sciama gives the subject a uniform speed and interprets this as a current. Again he takes the volume integral over the whole universe. This time it delivers a vector potential.

If the subject moves relative to the universe with a uniform speed **v**, then a vector potential **A** is generated.

$$\mathbf{A} = -\int_V \frac{\mathbf{v}\cdot\rho}{c\cdot r} dV \tag{2}$$

Both ρ and **v** are independent of *r*. Together with the constant *c* they can be taken out of the integral. Thus

$$\mathbf{A} = \Phi\cdot\mathbf{v}/c \tag{3}$$

Helmholtz decomposition

Sciama does not say this in his article, but the two volume integrals are in fact the two components of a vector field that play their role in the Helmholtz decomposition theorem.

$$\nabla\cdot\boldsymbol{F}(\boldsymbol{r}) = 4\cdot\pi\cdot Q(\boldsymbol{r}) \tag{4}$$

(5)

$$\nabla \times \boldsymbol{F}(\boldsymbol{r}) = 4 \cdot \pi \cdot \boldsymbol{I}(\boldsymbol{r})$$

$$\boldsymbol{F}(\boldsymbol{r}) = \nabla^2 \boldsymbol{A}(\boldsymbol{r}) = \boldsymbol{F}_1(\boldsymbol{r}) + \boldsymbol{F}_2(\boldsymbol{r}) \tag{6}$$

$$\boldsymbol{F}_1(\boldsymbol{r}) = \nabla \Phi(\boldsymbol{r}) \tag{7}$$

$$\boldsymbol{F}_2(\boldsymbol{r}) = -\nabla \times \boldsymbol{A}(\boldsymbol{r}) \tag{8}$$

$$\nabla \times \boldsymbol{F}_1(\boldsymbol{r}) = 0 \tag{9}$$

$$\nabla \boldsymbol{F}_2(\boldsymbol{r}) = 0 \tag{10}$$

$Q(\boldsymbol{r})$ represents the local charge density ρ. $\boldsymbol{I}(\boldsymbol{r})$ stands for the current density represented by the product of **v** and ρ. I took this from an old math reference book ("Mathematical Handbook for Scientists and Engineers"; G.A. Korn and T.M. Korn; McGraw-Hill;1968; section 5.7-3.)

This puts Sciama's approach in an interesting light. It is well known that Helmholtz decomposition divides the vector field in an irrotational vector point function and a solenoidal vector point function.

What makes the situation special is what we get when we reverse Sciama's interpretation. The current in the field corresponds to the movement of physical items!

Relations

Helmholtz decomposition only treats the stationary condition of the fields. It is related to the fact that the Fourier transform of a vector field can be split in a longitudinal and a transversal part. On its turn, this relates to the fact that the multidimensional Dirac function can be split in a longitudinal and a transversal part. As long as the whole situation stays stationary the two field components stay independent. However, as soon as a dynamic change happens, then the two fields get coupled. Maxwell's equations show these facts for the electromagnetic fields.

Dynamics

Sciama uses one of Maxwell's equations in order to show that the coupling of the fields **goes together with** an acceleration of the considered physical subject.

$$g = -\nabla\Phi - \frac{1}{c} \cdot \frac{\partial A}{\partial t} \approx \frac{\Phi}{c^2} \cdot \frac{\partial \mathbf{v}}{\partial t} \tag{11}$$

Since the contribution of the first term on the right is practically negligible, the field g corresponds to a change in time of the speed **v**. Thus, it corresponds with an acceleration of the considered physical item. Please notice the words "goes together with". It means that there exists no causal relation between the effects. The field does not cause the acceleration and the acceleration does not cause the field.

This is Sciama's explanation of the origin of inertia. In the same article he relates this fact to the interaction between two physical items, which to my opinion describes gravity rather than inertia.

Helmholtz decomposition only treats the stationary situation. In a curved space the Helmholtz theorem must be replaced by the Hodge decomposition theorem. However, the main relations and reasoning stay the same.

Aside from linear inertia there exists rotational inertia. This form controls centripetal forces and coriolis forces. They are treated in section 5 of Sciama's paper. Sciama interprets them as real inertial forces rather than as fictitious forces.

So far the model applies to all fields for which at all locations a charge density and a current density can be defined. Thus, it may hold for different types of fields, such as the gravity field and the electromagnetic fields. Now we proceed by extending upon the ideas of Sciama.

Other stationary relations

There exits another set of laws that control the stationary relations between physical items. This is the set of axioms of traditional quantum logic. This logic has an atomic orthomodular lattice structure which is the same as the lattice structure of the closed subspaces of an infinite dimensional separable Hilbert space. It means that a proposition about a physical item can be represented by a closed Hilbert subspace. Traditional quantum logic states nothing about dynamics. It also states nothing about fields.

Interpretation

When a physical item moves, then the atomic propositions that describe its properties change. It means the enveloping proposition that says everything about that item that can be said, is redefined. This also holds for the hierarchy of propositions that depend on this enveloping proposition. The corresponding subspaces are subspaces of the enveloping subspace. If this is interpreted in the light of what is stated above, then it means that there must exist something in quantum logic that represents the fields that accelerated the physical item. With other words, the propositions in the lattice of quantum logic influence each other when the propositions get redefined. This influence depends on the distance between actor and subject. So, there must be a notion of distance in quantum logic. This must be similar to a notion of distance in Hilbert space, but it is not the common notion of distance that derives from the norm. When the redefinition occurs such that it conforms to a uniform speed (inside a geodesic in a curved space) then the combined influences do not change the enveloping proposition. However when an acceleration occurs, then this goes together with a change of the enveloping proposition. This corresponds with a move in Hilbert space of the representation of the considered item with respect to the representations of the atomic propositions. These insights can guide the way to transform the current stationary traditional quantum logic into a more dynamic version of logic.

The movement treated here, is a movement of subspaces in Hilbert space. It is not yet an observed movement. Our usual notion of time, the coordinate time does not yet play a role there. The spaces that we talk about do not yet have a Minkowski signature.

Coordinate space

The fact that the system of propositions does not react on a uniform speed can be interpreted as the fact that in a uniform environment the approach of items in the direction of the movement is fully compensated by the increasing distance to items in the opposite direction. With respect to position of items the Hilbert space acts as an affine space. It means that absolute position is not a property of the items that are represented in Hilbert space. Besides of that there also does not exist an a priory preferred direction and there does not exist an a priory scale. Above we have seen that relative position in the form of distance between items is relevant for the influences of the fields. The coordinate space is obtained by starting from an orthonormal base and then evenly distribute the imaginary parts of the rational numbers of a quaternionic number field over them. These numbers and the corresponding base vectors become the eigenvalues ϙ and the eigenvectors |ϙ> of a normal operator. This operator is the coordinate operator Ϙ. Now restrict the competence of this operator to the difference between positions. It has the same significance as distance has, but it is multidimensional. This new notion of distance in Hilbert space differs from the notion of distance that derives from the norm and the inner product. The norm related distance between eigenvectors of a normal operator is a constant: $\sqrt{2}$.

When we speak about the coordinate distance between two vectors |f> and |g> in Hilbert space, then we mean the distance between the values of <f|Ϙ f>/<f|f> and <g|Ϙ g>/<g|g>.

When I use the word distance in the rest of the paper, I will mean the coordinate related distance. The coordinate space suffices as a setting for Sciama's formulas. It does not even need Hodge's approach. The canonical conjugate space of the coordinate space is the momentum space. This is the space in which the longitudinal and transverse components of the Fourier transforms of the fields are residing.

Two pictures

In contrast to the uniform background of the universe the distribution of items in the neighborhood of the considered subject is not uniform. As a consequence the fields in this environment are curved. We have to find a thing that couples the stationary fields and the moving Hilbert subspaces. We call this thing a manipulator. There are two pictures possible. The first is the **Heisenberg picture** in which the eigenvectors of observables move with respect to the subspaces. Here at each step the observables are redefined. This action can be established by a set of infinitesimal unitary transforms that work in a series of parallel trails. The second picture is the **Schrödinger picture** in which the eigenvectors are fixed and the subspace gets redefined. This action can be established by something that we will call a **redefiner**. The two pictures must conform.

The redefiner

It seems that quantum logic and Helmholtz decomposition together define an important part of the static relations that exist in physics. The fields appear to resist the disturbance of the interrelations in the lattice of quantum propositions. In dynamical sense this lattice might step from one static status quo to the next. After a step new conditions are established that again fulfill the laws that govern the static situation. If this is a proper interpretation, then it is likely that the progression step is taken universe wide.

The redefiner is a stepper. At each step the redefiner redefines the closed subspace that represents a physical item and the propositions about this item. The propositions are redefined in terms of atomic propositions. The subspaces are redefined in terms of the eigenvectors of observables. The redefiner does not touch the eigenvectors of observables. It is possible to let the redefiner act universe wide. That is over the whole Hilbert space. It steps from one stationary condition to the next. After the step the conditions have changed. The subspaces have been moved and as a consequence the fields got reconfigured. The steps of the redefiner define a **progression parameter**. It is enticing, but it is wrong to interpret that parameter as "time".

What we described here is a manipulators world. Let us now consider what is being manipulated. First try to find a means to define a useful topology in the Hilbert space such that we can use the distances between representations of propositions to account for the dependence of the influences/fields on that parameter. It means that a characteristic **locator** vector inside each representing subspace must be selected in order to get a sufficiently precise notion of distance. Next we can use the coordinate space and the coordinate operator as a kind of Hilbert GPS device.

We will not stick to real, complex numbers or quaternions for the eigenvalues of operators. We may even tolerate the 2^n-on hyper complex numbers of Warren Smith for this purpose. They have the nice property that in their lower 2^m dimensions they act as 2^m-ons. Thus in tiny local situations they act as complex numbers. With these tools we can compute what happens during the steps.

Minkowski

One important step must still be taken. In physics we observe that space corresponds with the imaginary part of a position quaternion for which the real part seems to have no physical meaning. Further, in physics observed spacetime has a Minkowski signature. We must find an explanation for these facts. The Minkowski signature defines the following time-like relation between the proper time Δt, the space step Δq and the coordinate time step $\Delta\tau$

$$\Delta t^2 = \Delta\tau^2 - \Delta q^2/c^2$$

A possible explanation can be given by the action of the redefiner when the action step is perpendicular to the space step and the coordinate time step is used to close the rectangular triangle. The action step $\boldsymbol{\Delta s}$ equals $c\cdot\boldsymbol{\Delta t}$.

$$\boldsymbol{\Delta\tau} = \boldsymbol{\Delta s} + \boldsymbol{\Delta q}/c$$

The bold font type indicates that we talk about $\mathbb{R}^3$ vectors or imaginary quaternions. This action can be achieved by an infinitesimal number transform that is only noticeable in Hilbert spaces where the number field is non-commutative.

The results of the Schrödinger picture must conform to the results of the Heisenberg picture. However, the redefiner does not touch the eigenvectors of operators. This means that the expectation values in the moved subspace must conform to expectation values of the eigenvectors that are moved by the collection of parallel acting unitary transforms in the Heisenberg picture. This must hold after every step. It means that the change of the expectation value corresponds to the action of an infinitesimal number transform. Such a transform has the form $q_{new} = u^*\cdot q\cdot u$ for expectation value q. We will take the coordinate operator Ϙ as the target operator. Its eigenvalues ϙ deliver the coordinates for the geometric representation of Hilbert space. The number transformation does not affect the real part of ϙ. That is why this real part does not show up in dynamical equations and it is why we choose for Ϙ to have only imaginary eigenvalues. Further, only differences between eigenvalues make sense.

The stepper action transforms the local GPS position ϙ such that it is transformed by an infinitesimal number transform $ϙ_{new} = u^*\cdot ϙ\cdot u$, where u is an infinitesimal transformer that is close to unity $u \approx 1 + \boldsymbol{\Delta s}$. $\boldsymbol{\Delta s}$ represents an infinitesimal action. In general u will be a 2^n-on, but at small scales the action can be seen as the action of a quaternion. It means that the imaginary part of ϙ gets a partial precession. $\boldsymbol{\Delta ϙ} = ϙ_{new} – ϙ$ is perpendicular to **ϙ** and **Δs**.

The result $\boldsymbol{\Delta q}$ of the infinitesimal number transform depends linearly on the size of the inter-distance $\boldsymbol{q}$ between actor and subject. On the other hand the strength $\boldsymbol{\Delta s}$ of the actuator depends inversely on the size of the inter-distance. So, these factors compensate each other. The displacement $\boldsymbol{\Delta q}$ is perpendicular to $\boldsymbol{\Delta s}$ and to the part of $\boldsymbol{q}$ that is perpendicular to $\boldsymbol{\Delta s}$.

When we close the rectangular triangle and call $\boldsymbol{\Delta \tau} = \boldsymbol{\Delta q}/c + \boldsymbol{\Delta s}$ the (coordinate) time step, then the resulting space has a Minkowski signature. This procedure introduces special relativity and a maximum speed of information transfer. It means that the number transformation splits the manipulating part from the manipulated part and at the same time the selected procedure creates an observable space with a Minkowski signature and a Lorentzian metric. The coordinate time is not the same as the progression parameter. The position is transformed. Its original real part does not play a role in the dynamical model. It is replaced by the coordinate time.

The action step $\boldsymbol{\Delta s}$ represents the combined influence of all fields. This action is not raised by uniform changes to the location ϙ, but it can be the result of non-uniformities in the fields.

After the step again a stationary status quo between fields and Hilbert subspaces is reestablished. However, the conditions have changed with respect to the situation before the step. The subspace has been moved and due to that fact the fields have been reconfigured. This holds for all representations of items in the Hilbert space.

Mechanism

The above considerations do not yet reveal the exact mechanism behind the establishment of physical dynamics. First of all, only macroscopic dynamics is considered. The deliberations say nothing about movements that take place inside physical objects. Next, the quaternion waltz transform delivers the structure on which a Minkowski signature can be based. However, there may be other mechanisms that perform this job. The infinitesimal transform u^*qu with $u = 1 + \Delta s$, is deduced from the conformance of the Heisenberg picture and the Schrödinger picture. It is no exact derivation. It suggests that fields locally add up in Δs to a value that can be represented by a construct consisting of scalars, vectors and tensors. The 2^n-ons might fit that purpose. At scales that become tinier this construct reduces from high n 2^n-on, via lower n 2^n-on, quaternion, complex number and finally an imaginary number. The lower dimension numbers inherit characteristics like a direction, sign selections and handedness from their higher dimensional ancestors.

In the abstraction to the Minkowski space, the size of manipulated value q is ignored. Only its variation Δq is preserved in the dynamic model. If q space is an affine space, then this becomes comprehensible. At the same time a different notion of progression, the coordinate time step $\Delta\tau$ is introduced. The original progression step Δt is ignored. With this abstraction, much of the original mechanism stays concealed in observed space.

Next steps

The mechanism of the Frenet-Serre frames can be used to analyze the influence of the local non-uniformity of the accumulated fields. This leads to concepts of geodesics both at the left side and on the right side of the number waltz. On the left side reside the progression parameter t and a landscape of active fields in a Euclidian coordinate space. On the right side resides the coordinate time that together with the observed position forms a curved observed space, which has a Minkowski signature and a Lorentzian metric that is pseudo-Riemannian. The curvature is due to the actions of the fields in the number transform.

The effects of the left sided geodesic can be used to create the Hamilton-Jacobi equation of motion. The effects of the right sided geodesic can be used to create the Lagrangian equations of motion. Both equations relate to a state vector, which directly relates to a state function.

Like the locator, a state vector is a characteristic vector. It characterizes the probabilistic properties of the subspace. It does not represent the physical item the way that this is done by the subspace. Together with an appropriate operator, such as the coordinate operator, it conforms to a probability amplitude function. This function specifies the probability that the eigenvalue will be observed in an immediately following measurement. The function is obtained by taking the inner product of the state vector with the eigenvectors of the operator and by taking the corresponding eigenvalues as function parameter.

Both the Hamilton-Jacobi approach and the Lagrangian approach neglect the fact that here not a single state vector, but instead a complete Hilbert subspace is moved. As long as these approximations are close enough, the theory becomes a useful quantum physical theory.

Optics

Wave mechanics has much in common with wave optics. The Hilbert subspace that represents a physical item has a spread in Hilbert space and a corresponding spread in the eigenspaces of normal operators. This is represented in the wave function. In that sense the position related wave function has much in common with the spread function that characterizes the blur of the image sided pictures in a uniform operating part of a linear operating imaging system. The image sided spread function equals the convolution of the object sided spread function and the point spread function (PSF). The physical fields that influence the physical item have an equivalent in the imaging device that transfers the image. The Fourier transform of the image sided spread function is equal to the product of the Fourier transform of the object sided spread function and the optical Fourier transforms (OTF's) of the imaging devices. When several imaging devices work in sequence, then the total optical transfer function of the imaging system equals the product of the transfer functions of the components.

In wave mechanics the wave function, which is taken just before the item moves gets the role of the object. After a movement through a piece of the fields the wave function has been changed. Its

Fourier transform then equals the product of the Fourier transform of the original wave function and the wave transfer functions (WTF's) of the fields that influence the item. If several steps are taken in sequence, then the transfer functions of the passed field pieces must be multiplied in order to get the overall result.

The measurement and the specification of the OTF must cope with the spatial non-uniformity of the imaging characteristics of the imaging devices and with the angular and chromatic distribution of the radiation. This also occurs with the WTF of physical fields.

From optics it is known that the modulation transfer function (MTF) is a proper imaging qualifier for inhomogeneous light imaging. In inhomogeneous imaging the imaging process can be properly described by ray tracing. Ray tracing has much similarities with the application of the path integral. However, ray tracing does not use arbitrary paths. In inhomogeneous imaging, phases appear to be scrambled. For holographic imaging the phase transfer function (PTF) or the whole OTF is the better measure. With holographic imaging the phases carry the depth information. Feynman's path integral can cover arbitrary paths because interference via the phases eliminates the contributions of non-realistic paths.

In optics the OTF depends on the position in the object space. Off axis the OTF is not rotationally symmetric. The OTF also depends on the angular distribution and the chromatic distribution of the radiation. These dependencies also hold for wave mechanics. They become important when a longer path is travelled.

Systems

A system is a local assembly of physical items that act as a single physical item. When a redefinition of physical items in terms of atomic propositions goes together with influences between items in the form of fields, then a redefinition of a system in terms of its components will certainly also have such effects. The redefinition may take different forms. It may be represented by an emission or absorption of a component or it may be a reshuffling of the components. The simplest case of reshuffling is a permutation of items that belong to the same category. A more complex situation is a periodic movement of one or more components within the realm of a system. Next each sequence of creation and annihilation is a form of redefinition.

The system has its own characteristic vectors. The wave function may depend on the permutation state of the system. For example for fermions an odd permutation changes the sign of the (position related) wave function. For bosons a permutation does not affect the wave function. Permutations of different categories of components go together with their own type of influence. Thus, there are fermionic fields and there are bosonic fields. Each of these fields has its own type of emission and absorption. Being fermion or boson relates to the spin type of the component. The annihilation and creation operators are closely related to the type of components involved and are also closely related to the type of fields involved. The annihilation/creation operators of fermions anti-commutate and the annihilation/creation operators of bosons commutate.

Statement:

Many of the effects described here will never be uncovered in a complex Hilbert space.