Knowledge and time

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Abstract

What is knowledge? How is it possible to know the world? What is time? These and other questions are the basics questions that Karl Friedrich von Weizsäcker asked himself his life long. In this essay I try to give a short summary of his thinking.

"Nature is older than humanity, humanity is older than knowledge."

— Carl Friedrich von Weizsäcker The Structure of Physics

1 Preface

The task is impossible. Karl Friedrich von Weizswrote 3 books (see bibliography), that belong together about how physics is possible, about mathematics and logic. Human knowledge and time. Total more than 2000 pages. How could I summarize this books in a few pages. I tried it, with all the difficulty of my own limited comprehension of the topics, my limited english knowledge and limited time at hand. So the essay is full of ideas, quotes without being quoted properly of von Weizsäckers work. So I want to apologize for that. I hope they essay can give a little idea of von Weizsäckers deep thinking about the foundation of physics and knowledge.

The last section about quantum mechanics is the only one that is different from Weizsäcker work and is my view of quantum mechanics a theory of knowledge.

2 Introduction

"Who lives cannot doubt everything."

— Carl Friedrich von Weizsäcker Zeit und Wissen

"This sheep is white." is a simple statement. How many sheep do I have to see until I can make the general statement "All sheep are white."? We know with Humes, that we never can conclude *logically* from a finite number of observations to a infinite number of possible observations. However that is how we learn. From finite experience we learn and can make prediction for the future. The statement "All sheep are white." cannot be *verified*, but a least *falsified.* We can doubt the general statement. “Look! There is a black sheep!” will be in general enough to falsify the general statement.

We cannot not doubt everything. But we can ask further: What did we already assume for the above reasoning to be true? Already in order to be able to make the first statement we must assume, that we *understand*, what a sheep is. The notion of ‘sheep’ must already exist as general term *eidos*. We must have a theory of what a sheep is: “All sheep have a specific DNA sequence.” The positivist schools believed that we could derive the general structure from the phenomenological given. But to express the phenomenological given, we must resort to given knowledge, to theory.

“This white looks sheepy.” What is the subject? What the properties? This way of questioning finally leads to the question, what is the substance? The substance is what stays. The properties are mostly contingent. ”This sheep” is the unique thing. His uniqueness is mostly represented by giving it a location in space an time. What if an object cannot be observed directly any more? An atom. Its uniqueness and individuality is questioned in quantum theory. Can we get rid of the subject as substance? This reminds me the construction of the set theory by Russel, where we have only sets of sets.

“This black thing is not a sheep.” The belief, that falsification can be done so easily seems to be as naive as the positivist dream to base our scientific language on the phenomenons. The fact, that the starlight has been bended by the sun does not necessarily include that space is curved. Light does not follow straight lines in the presence of gravity would be the simpler answer. The need of a theory independent measurement theory is urged by the constructivist approach of Lorenzen and Dingler and will be discussed later.

Hume did not doubt logic to be false. Neither we do, but in order for logic to be possible, there must be some constancy in nature. Objects should not change over time.

In order to learn from experience, we assumed that time is structured. The past is *factual*, the future is *possible*. The past is give to us in the presence as documents (memory) given in the presence. The future must be open, unknown. We assume that this structure of time is a precondition for scientific experience to be possible. However we’ll have to explain how this time structure is realized in our universe. We have to think about how evolution is possible in a universe where the entropy increases.

Doubting is a reflexive act. We observe our thought in our consciousness and doubt it afterwards. In order to doubt it, we must be able to think the *possibility* that a sheep could be black. Possibility is a future possibility that can become factual in the future presence. The ability to imagine different futures possibilities to happen in the present is a precondition to be able to do mathematics. In this essay I propose that evolution is the creation of forms out of forms. The continuation of this process in our consciousness without the need to be realized is seen as continuation of this evolutionary process.

Nowadays scientific belief is shaped from the deductive science of mathematics. From a few axioms we can derive a huge amount of phenomena. In the history of science we experienced the ”incredible effectiveness of mathematics”. We propose that mathematics is needed to give our experience an objective meaning. What remains is the great mystery of it unification power. This mystery made once belief, that god create the world in it image. Later on the hypothesis god was not needed any more. The mystery remained. In this essay a argue the quantum mechanics is the theory of measurement, that explains how information is transferred from one system to another. In order to be able to do that, it has to have a specific structure. Our ability to have objective knowledge of the phenomena is restricted to that structure.

3 Logic

Theorems in mathematics are deduced from the axioms with the help of logics. Logic in itself is a part of our language in which logic seems to have a very simple form. It is a rule system of language. It gains its simplicity through its relation to *truth*. It does not ask if a statement is true, but what form must a statement have to be always true. What is truth? Historically logic is the theory of the right deduction. “If all sheep are white and there is a sheep, then this sheep must be white.” The deduction can be resolved in sentences and the sentence in *terms* (”Begriffe”). The meaning of terms are rooted in the eidos philosophy. In mathematics the meaning of the terms are defined by their *structure*. For Kant analytical propositions are such where the term of the predicate is contained in the therm of the subject.

By focussing on the proper name of things (”this sheep”) a realistic-ontological construction of logic seems possible. The starting point is the thing. Terms are properties of things. Propositions assigns a property to a thing. Logic then is the way how to deduce from a general statement (“All sheep are white.”) the specific statement (“This sheep is white”). This might be our normal understanding of logic.

If we want logic to be independent of the ontology without returning to the eidos philosophy, we might prefer an operational construction of logic as theory of acting. Paul Lorenzen leads us in his game semantics to a notion of truth that is connected to provability.

With the interpretational problems of quantum mechanics in mind Von Weizsäcker felt urge to develop his ”time logic” that takes the structure of time as given and develops the way of talking about propositions in different times. He hoped to deduce the formalism of quantum mechanics in this way from a priori conditions. He failed to do that. He had to postulate the existence of a pure state, that is not decidable within a measurement context as an a posteriori postulate. However I his time logic remains interesting because it gives a meaning to notions like *actuality* and *potentiality* which reappears in the fundamental problems in mathematics and in physics in the interpretation of quantum mechanics. I’ll come back to that.

As the work of Paul Lorenzen is less known I’ll give a short introduction in the next subsection followed by a short sketch of von Weizsäckers time logic.

Game semantics - How to convince someone

In game semantics a proponent(P) tries to convince the opponent(O) that a general proposition (for example $A \to A$) is true for every insertion. If there is a general strategy to do that, the proposition is true. Such a dialog looks like that:

- P: $A \to A$
- O: I don’t belief that.
- P: Choose an example!
- O: This sheep s white.
- P: Prove it!
- O: Look!
- P: Ok. I see. But then: ”This sheep is white”

To prove the tertium non datur $A \vee \neg A$ the opponent can make a statement a. Then P can choose whether to the statement a or $\neq a$. It might be that P has no prove for a nor for $\neg a$. P has no strategy to always win the game. This is what Lorenzen calls the *hart* rule to play the game. It is the rules that one needs a prove for the statement to be true. This is the core of the constructivist view of mathematics. However there is also a *soft* way to play the game, where he can always win. The soft way to play would correspond to a view, where every formal mathematical statement is true or false independent of whether we have a formal prove.

Let us see a last example from quantum physics:

- P: $A \to (B \to A)$
- O: x (The particle is at position x)
- P: $B \to x$ (For any B, the particle is at position x)
- O: p (The opponent makes a momentum measurement that gives p)
- P: I cannot find the particle in position x any more

Of course the statement $A \to (B \to A)$ can be shown to be correct, if we use the proper time labels, and we have a registration of the first location measurement.

Can the rules of discussion decide, which logic one should use? We think logic to be true independent of our human behaviour. I cannot discuss that last sentence. I'm even not sure what it could mean. I conclude this section, I want to stress, that in the game semantics presented here, the statement A could be anything. A mathematical statement, a singular statement about the world, the proposition of physical law. Logic seems to be the basis of mathematics and mathematics the basis of physics. So it seems natural to clear and justify this basis first. But it seems to me, that the choice of the right logic (rules) depends highly one the subject. Whether we want to use it to explain, physics or mathematics or whatever we want to talk about.

Time logic (Zeitliche Logik)

It is impossible to summarize in this short essay the full contents of von Weizsäcker time logic. So I want to restrict myself on what I think is his intention to develop a time logic that is different from the classical logic and how time logic might serve this purpose. Finally von Weizsäcker hoped to be able to justify quantum mechanics from a priori conditions of experience. He failed to do that. Also his time logic remains unfinished. Yet I think one can learn a lot from it.

'We know classical logic and mathematics, classical physics, evolution theory, linguistic. Under usage of this knowledge we want to try to reconstruct the basis of classical logic and mathematics and time logic and from this to reconstruct physics and quantum mechanics, evolution theory... Our method is not hierarchical structure of science ... but a continuous hypothetical reflection' (I put single quotes because this is a very loose quote from the book Time and knowledge.)

Statements about the present

"Fire!", "This sheep is white" are examples of such statements. A statement is a sentence. It is linguistic act, a behaviour, a process. Each process happens in time. We can talk about processes. The singular aspect of the process is called *event*. What can be repeated in the process is a *process scheme*. A process scheme is something general. The same process can happen or be used in different situations. We can actually only talk about process schemes. For simply unique, we just have no words. However a process never strictly repeats itself. If we *talk* of reality, we never strike it exactly. But it is essential of our knowledge, what we know for two different events of the same process scheme, what their commonality is. An event is the realisation of a process scheme.

We can recognize Platons *eide* in von von Weizsäckers thinking. Eide never matches reality but we can only know reality through the eide.

For the process scheme von Weizsäckers adds more characteristics for a process scheme: *yes-no-principle, prevalence of the positive and adaptation.* I just want to make some remarks on these. A process scheme has a *Yes-no principle*, meaning an event either corresponds to the scheme or not. We see here that the law of noncontradiction and the tertium non datur are valid.

Prevalence of the positive says that there is an asymmetry in the yes-no principle. We usually say: “It rains’. The denying of the fact is mostly reflection of what was said. The term *Adaption* comes from biology and only makes sense in the context of behaviour. Animals act following their instincts. This means they follow a behaviour scheme. The behaviour scheme again is general. It has the yes-no principle: a situation triggers or triggers not a behaviour. Prevalence of the positive: a wolf reacts on the presence of a white sheep. He does not react on the sheep not being there.

Humans act. They can act, but must not. “There is a white sheep.” I can give him something to eat or make a pullover out of the wool. Humans do not need to act. Most of our action are spontaneous. But we can reflect afterwards on our action. this ability to reflect our action can be characterized be the term *imagination.* Acts that did not yet happen we can imagine as possible acts. Von Weizsäcker thinks, that every imagination, that can be spelled out exactly can be reduced to imaginations of possible acts.

As we will see, this lies the foundation to constructivistic reconstruction of mathematics like the one of Brouwer or Lorenzen.

In the evolution the perception of the process scheme (eide) comes before the perception of the uniqueness of an event. Today we could say, that if information storage is a scarce resource, it is more efficient to store our perception in ideal, simple forms. It seems also more adapted in the sense, that if I would store the exact look of my mother, I wouldn’t recognize her the next day any more.

How far have come? Already the seemingly simple statement about the present is not so simple to understand. I would say it is the most difficult. Because its simplicity hides all hidden assumptions we make. In the simple statement there is a law like connection to the possible actions and processes, which give the statement a meaning. This law like connections of possible action, if brought in a exact form are mathematical structures. ”Mathematics is the theory of structures.”

The rest of the time logic shall be summarized very,very shortly.

Predicative and free statements

“All sheep are white” , “Sheep is an animal.” This statements have a subject, that are followed by a predicate. Following Tugendhat the sense of the introduction of a subject is to free the sentence from its bounding to a specific situation. This is called a free statement. The free statement has a law like character. The meaning of a free statement can be defined as the condition of its verification in the present in the sense that it can be controlled in the future. Of course we know with Popper, that this cannot be done strictly.

Statements about the past

"It has rained yesterday." Statements about the past are like statements about the present bound to specific situation. So everything said before applies also here. The only question, that remains is how, we can know something of the past. The past is given to use only by documents in the present. From these we can infer, what has happened. The past is given to use as these condition for the becoming of these documents. In order to be able to make such an inference there must be laws that make this inference possible. The past is factual. A past event has either happened or not. We can apply boolean logic to past events.

Statements about the future

"It will rain tomorrow." We cannot know for sure. Future events are possible. The condition of verification of a statement about the future is again only in the present. But we'll have to wait until the future event becomes factual and can be checked. How comes the future is not given as fact to us? Physics should be able to explain this experience.

Here we see the circular non hierarchical thinking of von Weizsäcker. We use the experience of the structure of time as factual past and possible future to develop a logic, that is the basis for the mathematics and physics. And these the have to explain how such a structure of time is realized. A physical theory should have this *semantical consistency* to be able to explain its own preconditions.

Already before in the statement about the present, we defined in a way the meaning of such a statement as the imagination of the possible acts connected to that statement. The open future is already present in the present.

In quantum mechanics the open future is part of the theory. For events in the future, we can only make predictions of the probabilities of a event to happen (in the present). The future event is a *formal possible event*. Von Weizsäcker hopped to be able to derive a priori quantum mechanics a theory of possible knowledge from his time logic. He failed to do that. However I belief, that his time logic can show the semantical consistency of quantum mechanics.

Mathematics

> "Logic is the mathematics of truth and falsity.
> Mathematics is the theory of structures.
> Theory is the art of the true and the false.
> Art is the perception of forms through creation of forms. "
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> — Carl Friedrich von Weizsäcker Zeit und Wissen

In the philosophy of the researching mathematician neither logicism (Frege, Russel) nor intuitionism (Brouwer) succeed. Formalism (Hilbert) seems to be the main philosophy. The creative mathematician is not disturbed by questions brought to him from outside. Mathematician study structures as such. He does not ask himself, what they mean.

Some of the fundamental terms in classical physics are *things* and *space*. I do not discuss what a thing is. But lets look at the space. For Kant space was a form of pure intuition. A precondition of experience. I also think, that space is a pure intuition and a precondition of experience. But what does space mean. Kant thought that the euclidean space is the space of our intuition. The euclidean space is a space with a specific *structure*. He was wrong in thinking, that our intuition could say, which the structure of space is. Our intuition might be a bit to coarse grained to be able to decide, what structure our space has.

However if we want to do physics, we have to be able to give to space point distances, we have to know what a line is etc. We have to know the structure of space. We need mathematics.

Can we empirically decide, whether our space is curved or not? This is not sure. Light flying in curved lines might do just that: fly in curved lines in a flat space. The difficulty to strictly falsify the flat space might lie in the maybe fact that space is a precondition of our experience.

Dingler and Lorenzen tried to develop a proto physics in order to create measurement apparatuses, that do not depend on the theory that we want to try to falsify. They showed, that a flat space can be constructed by polishing three stones together. Two stones give a constant curvature on the surface. The third stone would give a flat space. Von Weizsäcker discussed with Dingler the objection, that because of the gravitational forces the stones might get distorted and during the process of polishing, they might end to dust. So the operation creating the measurement apparatus might fail. Dingler though that that was a crazy thought. Von Weizsäcker felt, that if the possibility of failing might be thinkable, it could be enough to say, that his measurement apparatus is independent of experience.

If we want to use mathematics as language for physics as science of our experience, we might have to try to *construct* mathematics and physics from basic notions that we understand in our experience. This is the structure of time. With time comes counting: Natural numbers. The integers are then not a enlargement of the set of natural numbers but as operations on natural numbers.

In von Weizsäckers view of the time logic and his reconstruction of mathematics the points in the *continuum* are given to us only potentially in the limit of a series of rational numbers.

However the quote at the beginning of this section points to mathematics as a creative activity, which where it will go might be beyond our imagination.

4 Physics

Phenomenologically we know what time is. The past is given to us factually. The future is open and we can imagine different potential futures. We know the history of our universe, from the big bang to the creation of solar systems to the emergence of primitive life forms to more complex life forms to humanity, who becomes concious of its own thoughts and who can create new abstract structures in their minds. And who can perceive them self as being in time. The structure of time seems to be a precondition of scientific knowledge. Can we explain the structure of time from our current physical knowledge?

In the last essay contest I tried to show, that only from reversible dynamics it follows, that the entropy increases in the future, but that entropy would also increase going to the past. This is completely time symmetric. Only if we take the time structure as given, we can argue, that the present was the future of a past time and that from there the entropy must have increased.

How is evolution possible despite the increase of entropy? Entropy can be describe as the potential information contained in a macro state. It is maximal in the equilibrium state. In this state the actual information is minimal. Thermodynamic Entropy is defined by the relation of the macro state and the micro state. Growth of entropy is then the increase of possible (unknown) micro states given the macro state. If we introduce a intermediate state between the macro state and the micro state. For example the types of the possible molecules, that can be build from the micro state, this could lead to a grow of the actual information of this intermediate state, as we can imagine, that the number of possible molecules (structures) can grow, if the number of possible micro states grow. So "evolution is the growth of potential information".

5 Quantum physics

The history of physics is a great success story. More and more phenomena have been explained with less and less theorems. A great process of unification. The last unification still waiting. Can we understand this success? In this section I want to present quantum theory as theory of measurement. Measurement as being the process of of transfer of information from one system to another. Let me present the idea first and afterwards draw some conclusions. An ideal measurement can be described by a von Neumann measurement scheme. For a qbit and continuous time such a measurement in the 3-direction looks like this

$$i\partial_t \begin{pmatrix} a \\ b \end{pmatrix} \otimes \psi(t) = \sigma^3 \begin{pmatrix} a \\ b \end{pmatrix} \otimes i\partial_3 \psi(t) \tag{1}$$

If ψ is a wave function located at 0 at the beginning, the it will travel up for the spin up part and travel down for spin down part. If we ask the interaction to be $SU(2)$ symmetric. We get the Weyl equation:

$$i\partial_t \begin{pmatrix} a \\ b \end{pmatrix} \otimes \psi(t) = \sigma^i \begin{pmatrix} a \\ b \end{pmatrix} \otimes i\partial_i \psi(t) \tag{2}$$

Here for a measurement in the 3 direction the wave function has to be prepared like this: x_3 located at 0 and for the other directions the momentum p must 0. So the direction of the measurement is determined by the initial state of the *measurement field*. I do not call it measurement apparatus, since there is no macroscopic object involved.

I don't think the model is the right one. However there are two things that are interesting:
1. The interaction is unique up to a local (in the up down indices) phase factor leading to a local phase invariance condition
2. If the measurement field is to be chosen in a pure momentum state, the field does not get entangled with the qbit and the qbit can be described separted from the field by a unitary development that breaks the $SU(2)$ symmetry.

So the idea is that the measurement field can never be switched off, so that usually the quantum object always gets entangled with the field, only not under very specific circumstances, where then the object can be described as a separated object.

The task is far away from being completed. But it gives a iterative procedure to arrive to more complex structures from the qbit. But the possible structures are limited by natural symmetry conditions to be fulfilled. In that way it is thinkable, that only a few atomic particles would appear, where al the others are build of.

The theory would be a theory of what could be possibly known.

References

[1] C.F. von Weizsäcker:*Zeit und Wissen*. Hanser, München 1992.

[2] C.F. von Weizsäcker:*Aufbau der Physik*. Hanser, München 1985.