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- for the Indiegogo crowdfunding campaign

A THEORY OF EVERYTHING

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Hi everyone,

its summer in Denmark (presumably this is the case in most of the northern hemisphere!) and thus I think its time for a newsletter to let you know how things are going with our research project and everything related hereto.

The past six months have been relatively quiet compared to the previous couple of years. Johannes and I have continued our analysis of the theory, that we have found; there are many interesting questions, which we are now looking into, exploring and discussing; and therefore we are at the moment working in several different directions. We are currently writing a paper, that deals with an inclusion of quantised matter in our framework and which we expect to finish within a few months. This results involves in my opinion some very interesting conceptual and philosophical aspects, which I would like to explain to you in some detail. But I prefer to do so after our results have been published, so what I will do now is to write this newsletter first and then write a followup once our paper is out.

Another important issue, which we have spent some time on during the past few months, is to get our recent preprints published. It is of course important for us to land these papers, which we believe contain very significant and important results, in some weighty journals. We have by now received some feedback and also criticism — some in the form of referee reports on our papers — and I thought that it would be interesting to write about this here so that you can get an idea about how the refereeing process works and how our papers might be perceived by other physicists.

So we'll start there, with the referees and their criticism.

Locality, Lorentz symmetry and the Wightman axioms

Let us begin with a brief recapitulation of what it is that Johannes and I have found —

— as you might recall from my previous newsletters a quantum theory consist of two basic components: there is an algebra of operators and there is a Hilbert space, where these operators 'live'. This is what quantum mechanics looks like and this is the form that we would like every quantum theory to have.

During the past years Johannes and I have constructed a very particular algebra, that consist of operators that simply encode — *roughly speaking* — how matter is moved around in space. This algebra, which we call the QHD algebra, is the algebra that we would like to view as a cornerstone in the quantum theory that we call *Quantum Holonomy Theory*.

Now, about a year ago we discovered a way to construct such a theory, i.e. to find a Hilbert space, where the QHD algebra fits in; a result, that we published in the form of a number of preprints last autumn. So that is where we stand now: we *know* that this theory exist in a strict mathematical sense of the word, that is what we have proven.

You may also recall that I explained to you that physicists have so far not succeeded in formulating the fundamental theory of Nature — the standard model of particle physics — in a similarly fashion as a rigorous (non-perturbative) mathematical entity. The standard model as we know it is what is called a *perturbative quantum field theory* — physicists have not been successful in casting this theory in the same form as quantum mechanics with an algebra and a Hilbert space.

The reason for this discrepancy — where on the one hand we have our theory, that exist non-perturbatively, and on the other hand a lot of similar quantum field theories including the standard model, which do not — can be summarised in a single word, which is *locality.*

Locality. We have discussed it before but lets pause here once more. What does locality mean?

Well, it means that important quantities in the theory can be localised to essentially single points. To take a famous and extreme example, at the Big Bang the entire Universe is purported to be localised in a single point of infinite curvature and energy. Or think of a black hole, where the curvature of space and time becomes infinite in its centre. Locality means that there is no limit to the degree that physical quantities can be localised in a theory.

Locality has been one of the cornerstones in theoretical physics in the past many decades. The entire framework of quantum field theory — which deals with the formulation of quantum theories that involves fields — is based on locality.

When physicists started thinking about how to formulate a quantum theory that involves not only particles, like quantum mechanics, but also relativistic fields such as the electro-magnetic fields, then they formulated a number of criteria, which they expected that such a theory should satisfy. These criteria comes in a number of different formulations, where perhaps the most famous is the *Wightman axioms.* This axiomatic system, which was first formulated by Arthur Wightman in the 1950's, has locality built into it.

And this is where we have received some criticism with our recent preprints. Because what we do does not — *it cannot* — satisfy the Wightman axioms. We are breaking the rules, here, so to say, and the rules, which we break have been around for a rather long time with a lot of people investing a lot of time trying to find solutions that obey them.

In our opinion this is natural, after more than *fifty years of research* that has *not* resulted in the formulation of a non-perturbative quantum theory of fields it might be worthwhile to

consider whether the rules, one has set up for this game, could be wrong. Perhaps the Wightman axioms need modification? This is, in fact, precisely what we propose.

And the modification that we suggest is tiny. The non-locality that we propose would only play a role at the Planck length, which is the incredibly short length scale where quantum effects of the gravitational field is expected to show up.

So this is where we stand. On the one hand we have decades of research based on the principles of the Wightman axioms with locality as one of the largest cannons. In the view of this approach a quantum theory that involves fields *is* local per definiton. This is simply one of the most important rules of this game — like soccer, where the fact that there is only *one* ball per match (and not one for each player, which might seem more democratic and fair and which would certainly be a rule that I would approve of) is a key rule — and if you don't have locality then you are not playing this game. And on the other hand we have our result, which shows that if you allow a tiny bit of non-locality then you can have a well-defined quantum theory of fields. A theory that actually exist. So who is right? How do you decide? In my opinion this is ultimately a question of empirical verification. Nature decides — we don't. And to propose that a fundamental theory must be non-local, like Johannes and me are doing, is ultimately a physical statement that needs experimental verification.

So this is what we reply when we are told that what we do is misguided — and our papers occasionally get rejected. And by the way, this is all rather normal, the refereeing process, which I am a fan of and generally believe works well, often involves some rather harsh language, which is, just as often, based in something substantial that is worth while discussing. So although this can be a little uncomfortable it is also a process where one can learn a lot (— at least that is what I try to tell myself).

One reason why the non-locality, that we suggest, makes some people nervous is that it has some rather significant side effects, where the most important one is that the Lorentz symmetry is broken.

The Lorentz symmetry? What is that — you might ask.

Think about rotations in space. Any physical theory must be invariant under rotations of the coordinate systems, which we use. It cannot have physical consequences if we rotate the way we map things in space around some axis; the forest cannot depend on our map. This is called rotational invariance or rotational symmetry. Now, the Lorentz symmetry is similar, but it also takes *time* into account. So a Lorentz transformation involves rotations not only in 3-dimensional space but in 4-dimensional space-time. This is a *key ingredient* in Einsteins theory of relativity (primarily the special theory of relativity).

So what we do *must* break Lorentz symmetry. And that is a rather serious thing to suggest. But the non-locality, that we suggest, happens at an extremely short scale — as I already explained to you — and it is not known if the Lorentz symmetry is an exact symmetry in Nature or if it could indeed be broken at a very short scale. This is something experimentalists have searched for and still do, especially as a possible signal indicating quantum effects of the gravitational field.

The Lorentz symmetry is in our case probably replaced by another, larger symmetry. This is something we are now looking into but haven't formulated yet, so I can't be too specific. But it seems likely that there will be another symmetry, that involves not only rotations in space-time but also scale transformations (zooming in). I'll keep you posted on this.

There is, however, a particular reason why I believe that the non-locality, which we encounter, is not only a feature that we might have to endure but in fact something to celebrate. Perhaps you recall that I have written about a simple argument, that suggest that a final theory must exist, that the ladder of scientific reductions, that takes us deeper and deeper into the fabric of Nature, must come to an end somewhere. According to this argument, which combines Einsteins theory of relativity with quantum mechanics, when you measure a distance shorter than the Planck scale, then your probe — the stone that you throw into the dark to see if a monster is waiting in there to eat you — will carry so much energy that it will cause space and time to curve so strongly that a black hole is created, and thus prevent any signal from travelling back to you. Distances shorter than the Planck length are *operational meaningless* — according to this argument. But if this argument is true, then non-locality is something that we must expect to show up in our theories! It is *precisely* what would characterise a fundamental theory — so in my mind this non-locality is something that makes me think that we're on the right track, that the ocean, that infinite nothingness, which we seek, is indeed lying over there behind those rolling green hills in front of us and that we simply need to continue down this walkway to find it. But whichever it is I think we'll find out relatively soon (but in this game 'soon' might involve years, not hours and days).

New Sponsors

Its a great pleasure to tell you that I have found a new sponsor of my work — the engineering company **TEGNESTUEN, HAUKOHL & KØPPEN** now sponsors my work with Johannes. I am of course enormously grateful for their support and look forward to converting their trust into scientific work — a huge thank you to Jens and Kasper for their trust.

Research grants

Another thing, which we have spent some time on, is to write a grant application. I would have liked our papers to have been accepted at a journal before spending energy on this but nevertheless we decided to write one now and try our luck — the good thing about such applications is that one can always try again later. There is a number of grants, which I consider applying for, but some of these application procedures are quite involved and therefore I don't consider it meaningful to try them before our new papers are properly published. The truth is that the platform, which I am applying from — I'm an unemployed researcher with a big hole in my academic CV — invites for an easy rejected from any grant committee. It will take some considerable counterbalance for this to work and a part of this would be to have our papers published.

We'll see how this works out. At the moment I have arranged my life in such a way that I can handle a considerable period without funding. I will, however, have to find some kind of funding at some point — but that funding does not necessarily have to be in the form of a research grant; I see a number of other possibilities.

I have not written much about research politics before — and I don't intend to do so now — but let me simply say that I think it could be beneficial for academia to have other paths to professional research mapped out: I don't think that the *only* way to do serious research is to have a university job and I think that there are times when its important to challenge the existing system by seeking out alternatives — that is also a part of what I am trying to do.

My book

In this newsletter I thought that I would also write a little about the book, that I have written and which is now in the process of being published.

One of the themes, that I wanted to write about in my book — apart from the immediate task of presenting and explaining what contemporary theoretical physics is all about, what problems we face and what direction we are heading; and apart from the fun part of writing about my many odd experiences in and around the world of science — is the larger picture: why are we searching for scientific truth, what do we hope to find, and — in my opinion the most interesting question — how might it affect us should we ever find what we seek, the final theory.

Imagine if we find that theory. What would such a discovery do to us, as people and as a society and civilisation?

I think that this question is part of what makes science truly intersting. What we do as scientists is to construct scientific theories and hold them up against empirical evidence. To probe reality in order to form a consistent, quantitative picture of her. But we do more than that. Science is not merely about reality, it is also about *our* relationship to reality. What is *our* role in this grand theatre of things? This is the question that, in my opinion, lurks behind all our efforts to understand the world that we find ourselves in. Ultimately we seek to understand ourselves.

This is a question that the mythologies used to deal with. The role of a mythology is to establish a relationship between people and the cosmos but today science has to a large degree — and certainly in the part of the world where I live — outcompeted and replaced the ancient mythologies and thus we turn to science to understand our place in the world. I think that the quest to find the final theory must in part be understood as an existential search. To understand why we are here, to find the answers, that the mythologies used to provide.

And this raises the question what might happen if we should ever find that theory? I am like many others convinced that it exist but what might it tell us? What kind of answer might it give us? And what will it *do* to us?

Will it leave us with a deep sense of clarity and understanding or will it open the door to an even greater mystery? Or will it tell us nothing at all?

And what are we going to do with ourselves, us seekers of truth, once this search has come to an end? Sit down and wait for eternity?

In my book I have spent some pages writing about these questions and about my own take on them. All great scientific discoveries have impacted our civilisation in ways that greatly surpasses the boundaries of their specific scientific disciplines and if there is one thing I am certain about then it is that the discovery of a final theory will impact our societies in ways that goes far beyond the strictly scientific.

It is still too soon to tell you when the book will come out but what I can tell you is that I've made some headway towards finding a publisher. So I'll keep you posted on this as well.

Have a nice summer!

With this I will end this newsletter. As always you can find all my newsletters on my homepage. As I said, I expect to write the next one relatively soon, when the next paper is out. Till then I will simply wish you a nice summer — or winter if your location is in the extreme south — and good luck in your quest to find that pollenpath!

Best wishes, take good care,

Jesper