Newsletter No. 2

(part B)

- for the Indiegogo crowdfunding campaign

A THEORY OF EVERYTHING

Cadiz, Spain 12.09.17

Hi everyone,

its finally time to complete the newsletter, that I started with a “part A” earlier this summer. Johannes and I have just posted two preprints on the archive, where we present a proof that our **quantum holonomy theory** exist in a rigorous mathematical sense. We have also discovered and proven the existence of a general framework of non-perturbative quantum field theory. We consider these results to be a major breakthrough. I would like to spend this newsletter to explain to you in a non-technical language what we have found and what I believe it means.

One of the most interesting features of the theory and framework, that we now present, is that it *appears* to rule out the space-time singularities purported to exist within black holes as well as the initial big bang singularity. If confirmed this will imply that black holes are not infinitely “deep” and that the big bang probably never happened — at least not as a bang.

But let us start with quantum field theory …

1. The problem with quantum field theory

As I have already discussed in previous newsletters the great unsolved problem in theoretical physics is how to reconcile Einsteins theory of general relativity with quantum theory. But there exist, in fact, a less famous but equally important problem, which is **to understand what a quantum theory of fields actually is**.

Let me explain this. All the theories, which we today know describe Nature to a very high degree of accuracy, are *field theories*. Einsteins theory of relativity and the standard model of particle physics. These theories describe the interaction of various *fields.*

- *what is a field?* I imagine you might ask.

Well, a field is simply an assignment of values to points in space. The electro-magnetic field is a collection of values assigned smoothly to all the points in space and time. So are the gravitational fields, the matter fields, Higgs fields and the various fields associated to the forces between elementary particle.

But the quantum mechanics that Niels Bohr, Schrödinger, Heisenberg, Einstein, Pauli, Dirac and many others discovered in the beginning of the 20th century is a quantum theory of *particles.* Quantum mechanics is a quantum theory of *finitely many* degrees of freedom. Fields theories, on the other hand, operate with *infinitely many* degrees of freedom (even uncountably many - and thats a lot!).

And this is the problem. Over the past almost 100 years physicists have attempted to construct a quantum theory of fields — and to some degree this endeavour has been a successful one: today we have a framework called *Quantum Field Theory* (QFT), which tells us how to work with quantised fields.

The problem is, however, that this framework only works in an approximate sense. The technical term is that it is a *perturbative* framework. It is a framework, that allows us to compute numbers to a very high degree of accuracy and hold them up against experimental data. This is what the standard model of particle physics is — and as such it is incredibly successful.

But here is the embarrassment: if we keep adding all the approximations in a QFT up we find that they eventually *diverge*. Our approximation only works up to a certain point, then the sum will begin to diverge. Now, this is a very technical subject, but what this means is that QFT's mostly don't exist in a strict mathematical sense. In fact, we do not have *any* example of a non-trivial quantum field theory in 3 dimensions plus time that exist in a strict mathematical sense!

This means that we do in fact **not** know what a quantum field theory really is. Not as a mathematical object.

And this is where Johannes and I have discovered something very interesting. We have found a general framework for quantum field theory and we have proven that it exist in a strict mathematical sense.

Of course, our primary motivation was to find a theory of quantum gravity — and this is still our aim — but what we have found seems to be much broader. Not only do we now have a proof that our candidate for a theory of quantum gravity — quantum holonomy theory — exist but we also find that our framework works for a very large class of field theories. This is quite remarkable.

2. Yang-Mills theory

To give you an idea of how important the question o formulating a framework for non-perturbative quantum field theory is let me tell you that the Clay Mathematics Institute in year 2000 published a list of 7 Millennium Problems in mathematics with a prize of 1 million US dollars for the solution of each of them. And one of these problems is precisely concerned with the rigorous formulation of a non-perturbative quantum field theory, namely a so-called Yang-Mills theory.

Yang-Mills theory is the name of a class of field theories, that describe for instance electromagnetism and also the strong and weak nuclear forces. And what the Clay Institute requires before they hand out their dough is a rigorous formulation of a quantum Yang-Mills theory as well as a proof that the *mass gap* in such a theory is strictly positive (the 'mass gap' has to do with the lowest possible energy level).

Now, the framework, that Johannes and I have found, works also for Yang-Mills theory and as we realised this we decided to write down also a general Yang-Mills theory.

It is important to say here, however, that more work is required before we can conclude that the non-perturbative Yang-Mills theory, that we have formulated, is in fact the same theory as we know from ordinary quantum field theory. One thing, that makes me believe that this will be the case, is that the Yang-Mills theory formulated in our framework gives the right theory in the classic limit. Another more technical reason is that the canonical commutation relations — what corresponds to the Heisenberg relations in quantum mechanics — in our framework are the same as the ones quantised in ordinary QFT-Yang-Mills theory except for a correction at the order of the Planck length. When one takes into account the specifics of our construction (technically: it is separable and strongly continuous) then I do not think that there is 'room' for such a framework without it coinciding with ordinary quantum field theory in the perturbative limit. But whichever it is, I am quite confident that we shall know relatively soon.

In any case, it is remarkable that we even have a candidate for a non-perturbative theory.

3. About locality

There is one reason, why the framework, that we have found, works and that is *locality*. Or rather *non-locality*.

In my previous newsletter I gave you a simple argument, that combines quantum mechanics with Einsteins theory of relativity, that explains why distances shorter than the Planck length are operational meaningless. Very briefly, the argument was that if you want to measure something shorter than the Planck length (which is an insanely short distance), then your test particle must have such a high energy that it will create a black hole and thus make it impossible for a signal to get back.

(think about it like this: to carry a very heavy letter your mailman must be so fat that the ground simply collapses beneath his feet and he disappears into a huge abyss — and is never able to get back out to deliver your letter)

Now, the framework, that Johannes and I have just published, has this type of non-locality build into it — in fact, this is where it departs from ordinary quantum field theory, where locality is one of the defining ingredients.

To explain what this really means I need to get a little technical. In a quantum theory we can in general compute the likelihood of different quantum transitions. For instance, we can compute the probability of an electron in an orbit around a nucleus to jump to a different orbit with a different energy. Or the probability of me suddenly sitting in the room next door (extremely low). Now, in the theory that we have found these transitions go between different field configurations (it could be different space-time geometries). So you can ask what is the probability of going from one configuration of a field to another. And here things become interesting because these quantum transitions depend on how the fields vary at different scales. If the fields vary mostly at very small scale (for instance the Planck scale) then the probability will be very *low* and vice versa, if the fields vary mostly at very large scales, then the probability of a transition will be much *larger*.

So what does this mean? Well, this scale dependency appears to rule out very extreme field configurations such as the space-time singularities purported to exist within black holes and the initial big bang singularity.

So if we are right and if what we have found is in fact related to a quantum theory of gravity, then this means that there probably was no big bang — and since we know that *something* extreme happened some 13 billion years ago it is probably a good guess that instead of a big bang there was a *big bounce.*

But again: we need to analyse and to understand this framework in more detail before we can say anything with certainty.

4. Actors, stages and theatre plays

Let me try to explain my work with Johannes with an analogy: *a quantum theory as a theatre play.*

A theatre play consist of three basic ingredients: an ensemble of **actors**, a **stage** and a **play**. The actors are obviously important, without actors there is no theatre, we need a group of people to play the various parts in the play. But once we have an ensemble of actors we also need a place for them to *work*, which is a theatre house, a stage. And finally, once we have both actors and a stage we can play Hamlet by Shakespeare or we can play something by Chekhov or Ibsen — that is, we need to choose what *play* we want to see.

This is what a quantum theory looks like. The actors are the algebra of operators — in our case we have chosen what we call the QHD algebra — and they live in a Hilbert space — what corresponds to the theatre stage — where they act and produce the numbers, which we can then compare to the data, which we get from experiments. But an algebra and a Hilbert space is not enough, we also need what corresponds to a play — which is the *dynamics*, the choice of a specific theory.

What Johannes and I have now are the first two ingredients and partially the third (and it is the second part, the Hilbert space, that is the hardest to find). But the point is that the actors and the stage, that we have found, can in fact accommodate various different plays. We can formulate a number of different theories in this framework, and among them are general relativity and Yang-Mills theory.

So this is the question, that we are interested in right now: is there one specific play — read: a specific theory — that fits particularly well into our framework? Is there something in the mathematics, that we have found, that prefers the formulation of one theory before all others? And if so, what is it?

5. What's next?

We have worked quite hard the past many months and therefore the first thing on our agenda now is **vacation**.

But once we have regained out strengths a little we will of course continue our work. And there are now a lot of open questions, which we would like to study.

What makes the situation so interesting now is that we have a completely solid platform to work from. The place we are at now is radically different from where we were, say, a year ago: then we were still searching for a theory — we had ideas, partial results, various hints and signs, but ultimately we were in the business of imagining and constructing and finding a fundamental theory. Now we have found this theory and thus our job is to determine what this theory actually contains. What is it that we have found? Is it really what we believe and hope it is — or is it something else?

Imagine that you have been searching for ancient buildings with a tiny torchlight in the dark. And then, after much effort and many detours and disappointments, you finally discover an entrance — and the entrance you have found looks promising, it looks like the entrance to a palace, or perhaps a pyramid, but you don't know yet, all you know is that at the end of the corridor that you have just entered you can see the faint contours of a number of doors and what you want to do now is to walk across the room and try all the doors, one after another, to see what's behind them.

This is where Johannes and I are now. We have found an entrance and have walked in — and now we're in the business of checking doors. For an explorer that is a good place to be.

6. Status of my book

A first draft of my book is now finished and submitted to a publisher. I did consider publishing it myself but I think that the book will benefit from passing through the hands of a professional editor — it is written it in english, which is not my native language — and thus I am now waiting for a reply. I expect this process to be quite prolonged, several months, perhaps even a year or longer. I have no prior experience with book publishing and have probably underestimated the time it takes to get a book out.

7. Finances

I think it is appropriate to also give you some information on how I have spent the money from the crowdfunding campaign so far. A good part of the money is still in my bank account — when the campaign started I registered a company in my name and have then paid a monthly salary of approximately 600 US$ from this company to myself. In this way I avoid paying too much tax and I can stretch the funds over several years. The size of this salary implies, of course, that my diet consist of a good deal of oatmeals, something that is good for my waistline.

8. Have a nice autumn and winter

With this I end this newsletter. Remember that you are very welcome to write to me if you have questions or if you have a topic, that you would like me to write about in my next newsletters — be it about physics and mathematics or about something else related to my work and crowdfunding campaign. I appreciate very much your feedback and I would like to encourage you to let me know if I should for example expand more on certain topics or if you find my explanations too technical.

I wish you all a super nice autumn, I expect to write the next newsletter some time early spring 2018.

All the best wishes, take good care,

Jesper