Newsletter No. 5

- for the Indiegogo crowdfunding campaign

A THEORY OF EVERYTHING

29.09.2018

Hi everyone!

Its time for a newsletter.

As I write this Johannes and I have just uploaded a new paper on our quantum holonomy theory to the archive (an online physics database) where it will be publicly available Monday. I have attached the paper to my mail to you. In this newsletter I will try to explain to you what we have found and what I believe it means.

In particular I will try to explain to you one aspect of what we have just found — and this is going to be a little complicated but I'll try to keep it as simple as possible and just convey to you the conceptual side of the story. Johannes and I often have a relatively high score on the international '*weird sci-fi nerdy*' scale — at least when viewed by non-experts — and that is probably also the case now. But as always I can assure you that the math behind all this is solid. We don't know if our theory actually describes the reality that we observe but we know with certainty that our math holds.

But lets get to it and let me start with the conclusion: what we have found is in my opinion a new interpretation of what is known as **fermionic quantum field theory**.

Now, take a deep breath and let me try to explain this statement.

As I am sure you all know there are two basic components in the theories, which today describe the reality that most of us enjoy spending our time in: there is **matter** and there are **interactions**. In physics we talk about fermions and bosons. The first constitute all the *stuff* around us, electrons, protons, neutrons, etc. — all the things that hurt when you bump into them in the dark when you go to the bathroom at night. These are all fermions. The second constitute the forces that interact with all this stuff. There is the electro-magnetic force, the strong and weak nuclear forces and then there is gravity. All bosons.

Now, from a mathematical point of view these two constituents look rather similar. Both fermions and bosons are described first as *fields* and secondly as *operator valued fields* — depending on wether we are including quantum effects or not. A field is simply a mathematical entity that assigns numbers to each point in space (and time) and the main difference between a fermionic and a bosonic field is how it behaves under certain symmetry transformations, for instance rotations. All fields have something called *spin* and it is this feature that tells us whether a particular field is a fermion or a boson.

Now, this story gets a little more complicated when it comes to quantum theory. In a quantum field theory one tries to impose the basic principles of a quantum theory on fields. It turns out that there are two ways to do this, one for bosons and one for fermions. In the bosonic case, which in many ways is the most natural one, the quantum fields have what is called Bose-Einstein statistics — this means that when you interchange two particles then you get an overall plus sign. And in the fermionic case the quantum fields have what is called Fermi-Dirac statistics — this means that when you interchange two particles then you have an overall minus sign.

When you first study this as a student this all seems rather exotic — okay, the math makes sense but why should we consider fields that behave in a certain weird way when we interchange two of its quantum constituents? To me at least this always seemed rather ad-hoc. There is some very deep math going on here but at a conceptual level I always felt that something was missing. A good explanation for instance. In my opinion this is what Johannes and I might have found.

To explain this I need us to consider Einsteins theory of relativity for a brief moment. You have all heard the story: Einstein tells us that space and time has curvature, the reality that we inhabit has a geometry and that geometry is dynamical, it is governed by its matter content.

Now, as I explained to you in a previous newsletter the theory that Johannes and I have found is in some ways similar to Einsteins theory. Like Einsteins theory of relativity it also describes curvature and geometry of an underlying space. But the space, that we are working with, is much, much larger than the space that Einsteins described (which is our 3 dimensional space plus time). The space that Johannes and I are working with is the space where each *point* is one particular configuration of our 3 dimensional space plus time. It is an infinite-dimensional space that contains all the possible geometries that our reality may have. So one point in this space is simply the case where our reality is completely flat, another point is the case where our reality is highly wrinkled in some particular way. There are infinitely many ways in which our reality can curve and our space contains all these different possibilities as different points[1]. And the theory, which Johannes and I have found, has to do with the geometry of this enormous space.

And here is then the point that I want to convey to you. In our theory the fermions emerge as a way to encode a geometry on this infinite-dimensional space. The fermions look the way they do and have the form they do because that is precisely how they need to be in order to be able to encode a geometry on this enormous space. So in this interpretation fermionic quantum field theory (which, I may add, is what we are all made of!) has a highly geometrical role. You can say that the fermions encode the geometry of the quantum theory.

Johannes and I have had this in mind for some years but its not until now that we have nailed its precise mathematical formulation.

So let me now try to summarise our theory in a few sentences: we start out with an algebra that simply contains information about how stuff is moved around in a 3-dimensional space. And bear this in mind: what matters here is the *action* of moving things around, the

---

[1] this is in fact not quite accurate. To be precise our space encodes only one aspect of a space-time curvature, its mathematical precise term is a configuration space of (spin) connections.

things themselves do not matter yet. And when you study this algebra, the mathematics involved, then you find that it involves what amounts to bosons. That is, forces, interactions. Now, this algebra naturally comes with a space — this is the infinite-dimensional space that I wrote about before — and when we formulate a geometry on this space then the fermions turn up. So from the very basic action of moving things around in space — the action of moving something from point ‘A’ to point ‘B’ — we get a quantum theory that naturally involves both bosons and fermions. This is what we call quantum holonomy theory. Whatever it is that we have found I find it highly intriguing and beautiful.

WHATEVER IT IS THAT WE HAVE FOUND …

This is a question that I have been asking myself a lot recently. What is it that we have found? When Johannes and I started working on our ideas some 15 years ago we had one particular aim: we were searching for a theory of quantum gravity. That is, a theory that combines Einsteins theory of relativity and the principles of quantum mechanics.

In particular we wanted to combine the machinery of **non-commutative geometry** with the framework known as **loop quantum gravity**. This is what we have been doing for all these years and last year we finally found what we had been looking for: a non-commutative geometry that involves the basic machinery from loop quantum gravity.

But once we had this it was also clear to us that what we had found didn’t quite look the way we had anticipated. It has one particular feature, which puts into question whether it really can be a theory of quantum gravity. This feature is what is called background dependency.

Let me explain this. Einsteins theory describes the geometry of space and time. So if we want to quantise this then we are really quantising the geometry of space and time itself. That would be the aim. But there is a problem here, because essentially all the known procedures of quantisation involves in one way or another a geometry against which one quantises the fields, which one would like to have in a quantum theory. This is for instance the case with the quantum theory known as the **standard model of particle physics**. This is what is called background dependency. The process of quantisation depends on a fixed geometry, a background. But clearly this will not do if we are to quantise the geometry of space and time itself. We cannot allow a second geometry to enter the picture in order to quantise the first one. So to quantise gravity we need a background *independent* procedure.

This is a major headache, that has been discussed for decades. Loop quantum gravity has a method that is background independent, but the price they pay for that independency seems to be that they cannot get back the theory of general relativity — Einsteins theory — which they started out with. This is the problem of finding a classical limit.

Now, it turns out that what Johannes and I have found is background dependent. It does depend on a fixed background. We tried for some time to do away with this aspect — we really wanted this to be a theory of quantum gravity and thus we wanted it to be background independent — but things like this are not easily hidden: its like a rash in the middle of your face, you can powder your nose all you want, it still shows.

So this has made us reconsider our entire project. What is it really that we are doing? We are still not certain but it seems clear to us that what we have found is indeed a candidate for a fundamental theory but whether that theory is a theory of quantum gravity is not completely clear to us. It does appear to solve some of the problems that one would like a theory of quantum gravity to solve — such as ensuring that one cannot measure arbitrary small distances in space. This latter point would for instance ensure that there was not big bang but rather a bounce and that black holes have a bottom.

To add a few more words about this I can tell you that our theory is based on what is called **gauge fields**. A gauge field is the basic mathematical constituent that describes the interactions found in the standard model of particle physics. The electro-magnetic force is described in terms of a particular gauge field and so are the strong and weak nuclear forces. A priori the fourth force, gravity, is not formulated in the same language but the indian theoretical physicist Abhay Ashtekar discovered in 1986 a particular formulation of Einsteins theory of relativity that is based on gauge fields too. This means that *all* the fundamental forces of Nature can be formulated in terms of gauge fields.

This is the reason why Johannes and myself are not completely certain what kind of theory we are dealing with. We know that it involves gauge fields but that does not tell us whether precisely what kind of force those gauge fields describe. This is what we are trying to figure out.

WHAT'S NEXT?

The place where Johannes and I now stand is quite interesting. Think of a scouting company send out ahead of the main force of an army in order to probe the terrain ahead. We have covered a lot of ground and have come to stretch of land that borders some interesting mountains ahead. Between us and the main force is a swampy area. Now, what we really ought do is to chart the swamp, make contact to the main force and build a bridge for it to advance. But you know what? Johannes and I are not very good at building bridges suitable for swamps. And we are much more interested in mountains than swamps. So we have decided to charge ahead and risk leaving the main force behind us.

To translate my metaphor: one option now would be to analyse in detail the connection between what we have found and quantum field theory. That would be a sensible thing to do but neither of us are really experts in quantum field theory — I used to work in that field as a Ph.D. student but that lies years behind me — and right now we are much more interested in finding out more about what our theory really contains. We are working in different directions, trying to analyse various mathematical aspects. I will keep you updated as soon as we find something interesting — if you never hear from me again then it probably means that we have encountered a wild grizzly bear or a hostile indigenous tribe!

ABOUT MY BOOK

Things are looking good for the book that I have written as a part of this crowdfunding campaign. It is scheduled to be published in Denmark next spring. It is still uncertain when it will appear in english (and thus when those of you who ordered it will get it) but I am quite hopeful that it will not take too much longer.

SOCIAL MEDIA

I am trying to get started on Twitter and you are all very welcome to connect with me there and also on Facebook. To be honest I am not really a hawk on social media but I think I will need it once my book gets out. I expect to produce a number of small videos to accompany the book launch. So I invite you all to connect with me there as well.

AND THEN SOMETHING ELSE …

During the past months I have written a couple of pieces about global warming — this is mostly in danish (a piece in Jyllands-Posten and a piece in POV International) but I also posted something in english on LinkedIn.

This has nothing to do with this newsletter or with my research project with Johannes, but I still wish to mention it. If we cook this planet then it doesn’t matter much whether we find the final theory or not. And since we know how *not* to cook our planet then I think that we should choose this option.

HAVE A NICE AUTUMN!

With this I will end my newsletter. I expect to write the next one some time early next year depending on whether something exciting happens in between.

As always you are more than welcome to write to me and ask questions. If there is something you would like me to explain in my next newsletter then please don’t hesitate to ask me.

I wish you all a most enjoyable autumn, a merry christmas and a happy new year!

Best wishes, Jesper