

# Complex Networks and Quantum Gravity

*Mathematicians investigating one of science's great questions—how to unite the physics of the very big with that of the very small—have discovered that when the understanding of complex networks such as the brain or the Internet is applied to geometry the results match up with quantum behavior. [6]*

*Vectors are great for describing the motion of a particle. But now suppose you need to analyze something more complicated, where multiple magnitudes and directions are involved. Perhaps you're an engineer calculating stresses and strains in an elastic material. Or a neuroscientist tracing the changing forces on water flow near nerve cells. Or a physicist attempting to describe gravity in the cosmos. For all that, you need tensors. And they might even help you unify gravitational theory with quantum physics. [5]*

*The magnetic induction creates a negative electric field, causing an electromagnetic inertia responsible for the relativistic mass change; it is the mysterious Higgs Field giving mass to the particles. The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass ratio by the diffraction patterns. The accelerating charges explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Relativistic Quantum Theories. The self-maintained electric potential of the accelerating charges equivalent with the General Relativity space-time curvature, and since it is true on the quantum level also, gives the base of the Quantum Gravity.*

## Contents

Preface.....	2
Popular questions about the Higgs Field: .....	2
How can we answer these questions? .....	2
Understanding of complex networks could help unify gravity and quantum mechanics .....	3
Tensor networks get entangled with quantum gravity .....	4
The Classical Relativistic effect .....	5
The Relativistic Quantum Mechanics .....	5
The Heisenberg Uncertainty Relation.....	5
The General Relativity - Electromagnetic inertia and mass.....	5
Electromagnetic Induction .....	5

Relativistic change of mass.....	6
The frequency dependence of mass .....	6
Electron – Proton mass rate .....	6
Higgs Field .....	6
The Higgs boson .....	7
What is the Spin? .....	7
The Weak Interaction .....	7
Higgs mechanism .....	7
Gravity from the point of view of quantum physics .....	8
The Gravitational force .....	8
The Graviton .....	9
Conclusions .....	9
References .....	9

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## Preface

### Popular questions about the Higgs Field:

- 1.) If the Higgs field is responsible for imbuing particles with mass, and mass is responsible for gravity, is it possible that the Higgs field will provide the missing link between general relativity and quantum mechanics i.e. could the Higgs field be the basis of a quantum theory of gravity?
- 2.) Can the theoretical Higgs Field be used as the “cause” of relativistic momentum or relativistic kinetic energy of a moving body?
- 3.) Does Einstein's General Relativity need to be adjusted for the Higgs field?
- 4.) Since the Higgs field gives most particles mass, and permeates all space, then GR needs the Higgs field to be a theory of space?
- 5.) So where GR is highly curved, the Higgs field is also curved? And does a highly curved Higgs field affect the way particles acquire mass? For that matter, a curved space-time would also curve electromagnetic field?

### How can we answer these questions?

There is an explanation of the magnetic effect caused by the electric current from the observed effects of the accelerating electrons, causing naturally the experienced changes of the electric field potential along the electric wire. The charge distribution is lowering in the reference frame of the accelerating charges linearly:  $ds/dt = at$  (time coordinate), but in the reference frame of the current

it is parabolic:  $s = a/2 t^2$  (geometric coordinate). The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators. [2]

## **Understanding of complex networks could help unify gravity and quantum mechanics**

The findings, published today in Scientific Reports, by researchers from Queen Mary University of London and Karlsruhe Institute of Technology, could explain one of the great problems in modern physics.

Currently ideas of gravity, developed by Einstein and Newton, explain how physics operates on a very large scale, but do not work at the sub-atomic level.

Conversely, quantum mechanics works on the very small scale but does not explain the interactions of larger objects like stars. Scientists are looking for a so called 'grand unified theory' that joins the two, known as quantum gravity.

Several models have been proposed for how different quantum spaces are linked but most assume that the links between quantum spaces are fairly uniform, with little deviation from the average number of links between each space. The new model, which applies ideas from the theory of complex networks, has found that some quantum spaces might actually include hubs, i.e. nodes with significantly more links than others, like a particularly popular Facebook user.

Calculations run with this model show that these spaces are described by well-known quantum Fermi-Dirac, and Bose-Einstein statistics, used in quantum mechanics, indicating that they could be useful to physicists working on quantum gravity.

Dr Ginestra Bianconi, from Queen Mary University of London, and lead author of the paper, said:

"We hope that by applying our understanding of complex networks to one of the fundamental questions in physics we might be able to help explain how discrete quantum spaces emerge. [6]

## Tensor networks get entangled with quantum gravity

Tensors accommodate multiple numerical values (a vector is actually a simple special case of a tensor). While the ideas behind tensors stretch back to Gauss, they were first fully described in the 1890s by the Italian mathematician Gregorio Ricci-Curbastro, with the help of his student Tullio Levi-Civita. (Tensors were given their name in 1898 by Woldemar Voigt, a German crystallographer, who was studying stresses and strains in nonrigid bodies.)

Ricci (as he is commonly known) was influenced by the German mathematician Bernhard Riemann in developing advanced calculus with applications to complicated geometrical problems. In particular, this approach proved valuable in studying coordinate systems. Tensors help make sense of the relationships in the system that stay the same when you change the coordinates. That turned out to be just the thing Einstein needed in his theory of gravity, general relativity. His friend Marcel Grossmann explained tensors to him and they became the essential feature of general relativity's mathematics.

And now, in a recent development, some physicists think tensors of a sort could help solve the longstanding problem of unifying general relativity with quantum mechanics. It's part of a popular new line of research using tensors to quantify quantum entanglement, which some physicists believe has something to do with gravity.

Entanglement is that spooky connection between separated particles that disturbed Einstein so much. Somehow a measurement of one of a pair of particles affects what you'll find when you measure its distant partner, or so it seems. But this "entanglement" is a clear-cut consequence of quantum physics for particles that share a common origin or interaction. It leads to some weird phenomena, but it's all very sensible mathematically, as described by the "quantum state." Entangled particles belong to a single quantum state.

A quantum state determines the mathematical expression (called the wave function) that can be used to predict the outcome of measurements of a particle — whether the direction that it spins is pointing up or down, for instance. When describing multiple particles — such as those in materials exhibiting quantum properties such as superconductivity — quantum states can get very complicated. Coping with them is made easier by analyzing the network of entanglement among those many particles. And patterns of such network connections can be described using tensors.

"Tensor networks are representations of quantum many-body states of matter based on their local entanglement structure," physicist Román Orús writes in a recent paper posted at arXiv.org. "In a way, we could say that one uses entanglement to build up the many-body wave function."

Put another way, Orús says, the entire wave function can be thought of as built from smaller tensor subnetworks, kind of like Legos. Entanglement is the glue holding the Legos together.

"Tensor network methods represent quantum states in terms of networks of interconnected tensors, which in turn capture the relevant entanglement properties of a system," Orús writes in another recent paper, to be published in *Annals of Physics*.

While the basic idea of tensor networks goes back decades, they became more widely used to study certain quantum systems in the 1990s. In the last few years, ideas from quantum information theory

have spawned an explosion of new methods using tensor networks to aid various calculations. Instead of struggling with complicated equations, physicists can analyze systems using tensor network diagrams, similar to the way Feynman diagrams are used in other aspects of quantum physics.

“This is a new language for condensed matter physics (and in fact, for all quantum physics) that makes everything much more visual and which brings new intuitions, ideas and results,” Orús writes.

Most recently, tensor networks have illuminated the notion that quantum entanglement is related to gravity. In Einstein’s general relativity, gravity is the effect of the geometry of spacetime. Analyses suggest that the geometry in which a quantum state exists is determined by the entanglement tensor network. [5]

## **The Classical Relativistic effect**

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field.

In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion. [1]

## **The Relativistic Quantum Mechanics**

The same thing happens on the atomic scale giving a  $dp$  impulse difference and a  $dx$  way difference between the different part of the not point like particles.

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial.

## **The Heisenberg Uncertainty Relation**

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a  $dx$  and  $dp$  uncertainty.

## **The General Relativity - Electromagnetic inertia and mass**

### **Electromagnetic Induction**

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

## Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

## The frequency dependence of mass

Since  $E = h\nu$  and  $E = mc^2$ ,  $m = h\nu / c^2$  that is the  $m$  depends only on the  $\nu$  frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the  $m_0$  inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation. [2]

## Electron – Proton mass rate

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. In the maximum intensity no diffraction patterns with equal intensity that is no fermions only bosons. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter. The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force.

In Quantum Field Theory (QFT), particles are described by excitations of a quantum field that satisfies the appropriate quantum mechanical field equations.

The excitations of the quantum field mean diffraction patterns in my theory. [2]

## Higgs Field

The Higgs mechanism is a result of something called a field that extends throughout space, even where no particles are present. This notion is probably most familiar to you from a magnetic field. You feel a force between a magnet and your refrigerator even when “nothing” is there. A field can fill “empty” space. The Higgs field extends throughout space. Elementary particles acquire their masses by interacting with this field. It is kind of like space is charged and particles get mass through their interactions with this charge.

The Higgs boson is not directly responsible for mass. The Higgs field is. The boson is a particle that tells us our understanding of this mechanism is correct. It also is a big clue as to where that field came from in the first place. Its discovery tells us that what we expected to be true was indeed correct, and it gives us clues as to what else might underlie the Standard Model. [4]

## The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

In my opinion, the best explanation of the Higgs mechanism for a lay audience is the one invented by David Miller. You can find it here: <http://www.strings.ph.qmul.ac.uk/~jmc/epp/higgs3.html> .

The field must come first. The boson is an excitation of the field. So no field, no excitation. On the other hand in quantum field theory it is difficult to separate the field and the excitations.

The Higgs field is what gives particles their mass.

There is a video that gives an idea as to the Higgs field and the boson. It is here:

<http://www.youtube.com/watch?v=RIg1Vh7uPyw> . Note that this analogy isn't as good as the Miller one, but as is usually the case, if you look at all the analogies you'll get the best understanding of the situation.

## What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

## The Weak Interaction

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the  $T_{\max}$  change and the diffraction patterns change. [2]

## Higgs mechanism

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with

the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the  $W^\pm$ , and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

## Gravity from the point of view of quantum physics

### The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Big Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass ratio  $M_p=1840 M_e$ . In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of



these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

## The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

## Conclusions

"What we can see is that space-time at the quantum-scale might be networked in a very similar way to things we are starting to understand very well like biological networks in cells, our brains and online social networks." [6]

"By pushing this idea to the limit," Orús notes, "a number of works have proposed that geometry and curvature (and hence gravity) could emerge naturally from the pattern of entanglement present in quantum states."

If so, tensor networks could be the key to unlocking the mystery of quantum gravity. And in fact, another clue to quantum gravity, known as the holographic principle, seems naturally linked to a particular type of tensor network. That's a connection worth exploring further. [5]

The electric currents causing self maintaining electric potential is the source of the special and general relativistic effects. The Higgs Field is the result of the electromagnetic induction. The Graviton is two photons together.

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