

# Hybrid Quantum Internet

*Advances in quantum communication will come from investment in hybrid technologies, explain Stefano Pirandola and Samuel L. Braunstein. [9]*

*A University of Oklahoma-led team of physicists believes chip-based atomic physics holds promise to make the second quantum revolution--the engineering of quantum matter with arbitrary precision--a reality. With recent technological advances in fabrication and trapping, hybrid quantum systems are emerging as ideal platforms for a diverse range of studies in quantum control, quantum simulation and computing. [8]*

*The one thing everyone knows about quantum mechanics is its legendary weirdness, in which the basic tenets of the world it describes seem alien to the world we live in. Superposition, where things can be in two states simultaneously, a switch both on and off, a cat both dead and alive. Or entanglement, what Einstein called "spooky action-at-distance" in which objects are invisibly linked, even when separated by huge distances. [7]*

*While physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena, computer scientists are searching for technologies to build the quantum computer.*

*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.*

*The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.*

*The diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the Relativistic Quantum Theory and making possible to build the Quantum Computer.*

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## Preface

While physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena, computer scientists are searching for technologies to build the quantum computer.

Australian engineers detect in real-time the quantum spin properties of a pair of atoms inside a silicon chip, and disclose new method to perform quantum logic operations between two atoms. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

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.

## Unite to build a quantum Internet

Almost 25 years ago, physicists discovered a way of 'teleporting' a quantum system from one place to another without moving it. There are physical limits to such teleportation: nothing can be transmitted faster than the speed of light; and Heisenberg's uncertainty principle restricts what we can know about the state of a quantum system at a given time. Nevertheless, the transported system is a replica that perfectly mimics the original, thanks to the weirdest feature of quantum mechanics — entanglement. Described by Albert Einstein as “spooky action at a distance”, this property enables distinct quantum systems to become intimately correlated so that an action performed on one has an effect on the other, even for systems that are too far apart to physically interact.

Quantum states are fragile and cannot be sent through conventional lines of communication; quantum teleportation offers a reliable and efficient way to transfer quantum information across a network. It provides the most promising mechanism for a future quantum internet, with secure communications and a distributed computational power that greatly exceeds that of the classical Internet.

Quantum information comes in a variety of forms — the polarization state of a photon, the spin of an electron or the excitation state of an atom. Many technologies have been developed for teleporting such states. But there are practical restrictions on what can be teleported, and how. Certain technologies will be better than others for particular tasks, and each has its limitations. Polarized photons have been used to transfer quantum information over more than 100 kilometres, but only probabilistically. Superconducting devices can send information without losses through a chip, but only for a split second, after which the information is scrambled by interactions with the environment.

Hybrid approaches might overcome these limitations. A global, distributed quantum computer or internet will need to integrate different sorts of quantum technologies. For example, light-based teleportation, for long-distance quantum communication, will need to be linked to matter-based quantum memories and quantum computers for data storage and data processing. Here, we outline the main challenges and call for researchers to focus on the interfaces between quantum technologies as well as advancing individual methods.

## Two approaches

The best technique at present for long-distance communication is the teleportation of quantum information that is embedded in optical light. Quantum information — measured in units known as quantum bits, or qubits — can be encoded either by the discrete properties of a pulse of light, such as its polarization state, or by the continuous aspects of an electromagnetic wave, such as the intensity and phase of the wave's electric field. To teleport this information, both the sender and receiver must own one of a pair of entangled quantum systems (see 'Quantum teleportation'). When the sender alters the state of their system, the receiver's system is also affected.

Polarization qubits perform best in terms of distance — holding a record of 143 kilometres. But currently, only 50% of these qubits can be teleported.

Teleportation requires that the sender can carry out an operation known as a Bell detection, in which the polarizations of two qubits are correlated perfectly in four possible configurations. But there is no practical way to measure all four outcomes. Simple optics and photodetectors can distinguish two, at most. Extra qubits add technical complications.

Inconclusive outcomes such as these are acceptable for quantum cryptography, in which secret keys are generated at random, and part of the information can be discarded. But quantum communication demands that information is sent in full.

Teleportation over long distances brings further technical challenges, such as compensating for atmospheric turbulence and movement of the ground. It is also likely to require new technologies to synchronize both ends — using atomic clocks, for example. Modern classical communications rely heavily on satellite technology. Transferring quantum information to the ground from a satellite in a low Earth orbit (at an altitude of about 500 kilometres) is within the reach of current technology, thanks to ground-based telescopes with metre-sized apertures that can collect most of the light from a beam that has spread out during its passage from a satellite. But transferring quantum information from the ground to a satellite, or between satellites, is more difficult because satellites cannot carry large optics.

By contrast, it is easy to measure all Bell-detection outcomes for continuous-variable systems such as electric fields, using only simple linear optics and standard photodetectors. Such systems can convey simultaneously the equivalent of many qubits, which makes them appealing for use in high-rate quantum communications<sup>6</sup>. But because the range of distances over which they can teleport is currently limited, continuous-variable systems are used less frequently than are qubits.

Approaches are needed that combine the best features of discrete variables (teleportation over long distances) with those of continuous variables (fast, deterministic teleportation). Teleportation that

uses such combinations has been demonstrated over table-top distances. One experiment<sup>7</sup> combined a discrete qubit with a continuous-variable entangled source to teleport quantum information deterministically. Further studies should help both to extend the distances covered by these experiments and to integrate qubits with other types of quantum technologies, including quantum memories for the storage of teleported information.

Studies of hybrid technologies will require greater collaboration and interaction between teams with different specializations.

## Quantum internet

One of the greatest challenges for implementing a globally distributed quantum computer or a quantum internet is entangling nodes across the network<sup>8</sup>. Qubits can then be teleported between any pair and processed by local quantum computers.

Ideally, nodes should be entangled either in pairs or by creating a large, multi-entangled 'cluster state' that is broadcast to all nodes. Cluster states that link thousands of nodes have already been created in the laboratory<sup>9</sup>. The challenges are to demonstrate how they might be deployed over long distances, as well as how to store quantum states at the nodes and update them constantly using quantum codes.

Quantum networks require memories to store quantum information, ideally for hours — shielding it from unwanted interactions with the environment. Such memories are needed for quantum computing at nodes and also for the faithful, long-distance distribution of entanglement through quantum repeaters.

Quantum memories need to convert electromagnetic radiation into physical changes in matter with near-perfect read–write fidelity and at high capacity. 'Spin ensembles' represent one type of quantum memory. Ultracold atomic gases consisting of about one million atoms of rubidium can convert a single photon into a collective atomic excitation known as a spin wave. Storage times are approaching the 100 milliseconds required to transmit an optical signal across the world.

Solid-state quantum memories are even more appealing. Crystalline-solid spin ensembles — created by inserting lattice defects known as nitrogen-vacancy centres into diamonds, or by doping rare-earth crystals — can remain coherent for hours at cryogenic temperatures.

Superconducting qubits, which are defined by physical quantities such as the charge of a capacitor or the flux of an inductor, interact within a quantum processor by releasing and absorbing microwave photons. For the successful integration of solid-state quantum memory, reversible storage and retrieval of quantum information must be made possible. This will require an efficient interface between the microwave photons and the atomic spins of a solid-state quantum memory that is attached to the processor. If successful, this hybrid technology would become the most promising architecture to be scaled up into a large, distributed quantum computer.

“The development of a quantum internet needs investment on a much larger scale.”

The incorporation of superconducting processors into a quantum internet also requires that locally processed and stored microwave photons interface with optical signals (often carried in fibres), which are the most robust carriers of quantum information over long distances. A hybrid solution, known as an optomechanical quantum transducer, is emerging<sup>10</sup>. These devices exploit nanomechanical oscillators (such as microscopic vibrating mirrors) to transform optical photons into microwave photons, and vice versa. But their efficiency must be improved to ensure that qubits are not lost during the conversion process and that all of their quantum features are preserved. The conversion efficiency is currently about 10% (ref. 10).

The next 15 years could see the construction of a hybrid-technology quantum internet. In the vision we outline, superconducting quantum processors will be integrated with solid-state memories for local quantum storage and then augmented with microwave–optical transducers for long-distance optical communication.

After two remote nodes have been connected in this way, entanglement can be distributed between distant quantum processors to enable teleportation.

## Next steps

To make this vision a reality, the following three steps should be priorities for quantum teleportation science.

First, more research — theoretical and experimental — is needed at the interface between discrete and continuous variables; dedicated conferences would help.

This would enable us to blend these currently distinct approaches to exploit the best of both. Satellite experiments with polarization qubits should be pursued, and continuous-variable teleportation should be extended beyond the lab for communication within cities using free space or optical fibres.

Second, the most successful technologies will be those that integrate data communication and data storage. We need to invest in the development of a more efficient interface between superconducting quantum processors and solid-state quantum memories. This would improve the performance of the storage and retrieval of microwave photons. A tangible next step could be on-chip teleportation between a superconducting qubit and a nitrogen-vacancy centre in a local quantum memory.

Third, investment should be made in technologies that show promise of scalability. For example, microwave–optical transducers that can efficiently connect microwave photons with optical photons on a chip for long-distance quantum communication should be designed and integrated. Two remote chips could be linked by paired transducers, paving the way for long-distance quantum teleportation between superconducting qubits.

These steps will necessitate a closer interaction between researchers in superconducting quantum computing and those who are developing long-distance quantum optical communications. Industry must also be involved, especially multinational corporations that are leaders in computer hardware

and telecommunications. Quantum technology is attracting private stakeholders, but the development of a quantum internet needs investment on a much larger scale. [9]

## **Second quantum revolution a reality with chip-based atomic physics**

A University of Oklahoma-led team of physicists believes chip-based atomic physics holds promise to make the second quantum revolution--the engineering of quantum matter with arbitrary precision--a reality. With recent technological advances in fabrication and trapping, hybrid quantum systems are emerging as ideal platforms for a diverse range of studies in quantum control, quantum simulation and computing.

James P. Shaffer, professor in the Homer L. Dodge Department of Physics and Astronomy, OU College of Arts and Sciences; Jon Sedlacek, OU graduate student; and a team from the University of Nevada, Western Washington University, The United States Naval Academy, Sandia National Laboratories and Harvard-Smithsonian Center for Astrophysics, have published research important for integrating Rydberg atoms into hybrid quantum systems and the fundamental study of atom-surface interactions, as well as applications for electrons bound to a 2D surface.

"A convenient surface for application in hybrid quantum systems is quartz because of its extensive use in the semiconductor and optics industries," Sedlacek said.

"The surface has been the subject of recent interest as a result of its stability and low surface energy. Mitigating electric fields near 'trapping' surfaces is the holy grail for realizing hybrid quantum systems," added Hossein Sadeghpour, director of the Institute for Theoretical Atomic Molecular and Optical Physics, Harvard-Smithsonian Center for Astrophysics.

In this work, Shaffer finds ionized electrons from Rydberg atoms excited near the quartz surface form a 2D layer of electrons above the surface, canceling the electric field produced by rubidium surface adsorbates. The system is similar to electron trapping in a 2D gas on superfluid liquid helium. The binding of electrons to the surface substantially reduces the electric field above the surface.

"Our results show that binding is due to the image potential of the electron inside the quartz," said Shaffer. "The electron can't diffuse into the quartz because the rubidium adsorbates make the surface have a negative electron affinity. The approach is a promising pathway for coupling Rydberg atoms to surfaces as well as for using surfaces close to atomic and ionic samples."

A paper on this research was published in the American Physics Society's Physical Review Letters. The OU part of this work was supported by the Defense Advanced Research Projects Agency Quasar program by a grant through the Army Research Office, the Air Force Office of Scientific Research and the National Science Foundation. [8]

## **Quantum computing will bring immense processing possibilities**

But weird or not, quantum theory is approaching a century old and has found many applications in daily life. As John von Neumann once said: "You don't understand quantum mechanics, you just get used to it." Much of electronics is based on quantum physics, and the application of quantum theory

to computing could open up huge possibilities for the complex calculations and data processing we see today.

Imagine a computer processor able to harness super-position, to calculate the result of an arbitrarily large number of permutations of a complex problem simultaneously. Imagine how entanglement could be used to allow systems on different sides of the world to be linked and their efforts combined, despite their physical separation. Quantum computing has immense potential, making light work of some of the most difficult tasks, such as simulating the body's response to drugs, predicting weather patterns, or analysing big datasets.

Such processing possibilities are needed. The first transistors could only just be held in the hand, while today they measure just 14 nm – 500 times smaller than a red blood cell. This relentless shrinking, predicted by Intel founder Gordon Moore as Moore's law, has held true for 50 years, but cannot hold indefinitely. Silicon can only be shrunk so far, and if we are to continue benefiting from the performance gains we have become used to, we need a different approach.

## Quantum fabrication

Advances in semiconductor fabrication have made it possible to mass-produce quantum-scale semiconductors – electronic circuits that exhibit quantum effects such as super-position and entanglement.

The image, captured at the atomic scale, shows a cross-section through one potential candidate for the building blocks of a quantum computer, a semiconductor nano-ring. Electrons trapped in these rings exhibit the strange properties of quantum mechanics, and semiconductor fabrication processes are poised to integrate these elements required to build a quantum computer. While we may be able to construct a quantum computer using structures like these, there are still major challenges involved.

In a classical computer processor a huge number of transistors interact conditionally and predictably with one another. But quantum behaviour is highly fragile; for example, under quantum physics even measuring the state of the system such as checking whether the switch is on or off, actually changes what is being observed.

Conducting an orchestra of quantum systems to produce useful output that couldn't easily be handled by a classical computer is extremely difficult.

But there have been huge investments: the UK government announced £270m funding for quantum technologies in 2014 for example, and the likes of Google, NASA and Lockheed Martin are also working in the field. It's difficult to predict the pace of progress, but a useful quantum computer could be ten years away.

The basic element of quantum computing is known as a qubit, the quantum equivalent to the bits used in traditional computers. To date, scientists have harnessed quantum systems to represent qubits in many different ways, ranging from defects in diamonds, to semiconductor nano-structures or tiny superconducting circuits.

Each of these has its own advantages and disadvantages, but none yet has met all the requirements for a quantum computer, known as the DiVincenzo Criteria.



The most impressive progress has come from D-Wave Systems, a firm that has managed to pack hundreds of qubits on to a small chip similar in appearance to a traditional processor.

## Quantum secrets

The benefits of harnessing quantum technologies aren't limited to computing, however. Whether or not quantum computing will extend or augment digital computing, the same quantum effects can be harnessed for other means. The most mature example is quantum communications.

Quantum physics has been proposed as a means to prevent forgery of valuable objects, such as a banknote or diamond, as illustrated in the image below. Here, the unusual negative rules embedded within quantum physics prove useful; perfect copies of unknown states cannot be made and measurements change the systems they are measuring. These two limitations are combined in this quantum anti-counterfeiting scheme, making it impossible to copy the identity of the object they are stored in.

The concept of quantum money is, unfortunately, highly impractical, but the same idea has been successfully extended to communications. The idea is straightforward: the act of measuring quantum super-position states alters what you try to measure, so it's possible to detect the presence of an eavesdropper making such measurements. With the correct protocol, such as BB84, it is possible to communicate privately, with that privacy guaranteed by fundamental laws of physics.

Quantum communication systems are commercially available today from firms such as Toshiba and ID Quantique. While the implementation is clunky and expensive now it will become more streamlined and miniaturised, just as transistors have miniaturised over the last 60 years.

Improvements to nanoscale fabrication techniques will greatly accelerate the development of quantum-based technologies. And while useful quantum computing still appears to be some way off, it's future is very exciting indeed. [7]

## Quantum Computing

A team of electrical engineers at UNSW Australia has observed the unique quantum behavior of a pair of spins in silicon and designed a new method to use them for "2-bit" quantum logic operations.

These milestones bring researchers a step closer to building a quantum computer, which promises dramatic data processing improvements.

Quantum bits, or qubits, are the building blocks of quantum computers. While many ways to create a qubits exist, the Australian team has focused on the use of single atoms of phosphorus, embedded inside a silicon chip similar to those used in normal computers.

The first author on the experimental work, PhD student Juan Pablo Dehollain, recalls the first time he realized what he was looking at.

"We clearly saw these two distinct quantum states, but they behaved very differently from what we were used to with a single atom. We had a real 'Eureka!' moment when we realized what was happening – we were seeing in real time the `entangled' quantum states of a pair of atoms." [5]

Researchers have developed the first silicon quantum computer building blocks that can process data with more than 99 percent accuracy, overcoming a major hurdle in the race to develop reliable quantum computers.

Researchers from the University of New South Wales (UNSW) in Australia have achieved a huge breakthrough in quantum computing - they've created two kinds of silicon quantum bit, or qubits, the building blocks that make up any quantum computer, that are more than 99 percent accurate.

The postdoctoral researcher who was lead author on Morello's paper explained in the press release: "The phosphorus atom contains in fact two qubits: the electron, and the nucleus. With the nucleus in particular, we have achieved accuracy close to 99.99 percent. That means only one error for every 10,000 quantum operations."

Both the breakthroughs were achieved by embedding the atoms in a thin layer of specially purified silicon, which contains only the silicon-28 isotope. Naturally occurring silicon is magnetic and therefore disturbs the quantum bit, messing with the accuracy of its data processing, but silicon-28 is perfectly non-magnetic. [6]

## Quantum Entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

## The Bridge

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]

## Accelerating charges

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.

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

### Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that 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).

### Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on  $\Delta x$  position difference and with a  $\Delta p$  momentum difference such a way that they product is about the half Planck reduced constant. For the proton this  $\Delta x$  much less in the nucleon, than in the orbit of the electron in the atom, the  $\Delta p$  is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

### Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on  $\Delta x$  position with  $\Delta p$  impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

### Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

### The Relativistic Bridge

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. 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. [2]

## The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. 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.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a  $1/2$  spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with  $1/2$  spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the

proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with  $\frac{1}{2}$  spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

### **The General Weak Interaction**

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.

The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.

We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater than subatomic matter structures as an electric dipole change. There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.

The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

### **Fermions and Bosons**

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

### **Van Der Waals force**

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will

have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

## 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.

### Electron – Proton mass rate

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. [2]

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.

## 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 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.

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 and Quantum Gravity

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.

### 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 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

Quantum communication systems are commercially available today from firms such as Toshiba and ID Quantique. While the implementation is clunky and expensive now it will become more streamlined and miniaturised, just as transistors have miniaturised over the last 60 years. Improvements to nanoscale fabrication techniques will greatly accelerate the development of quantum-based technologies. And while useful quantum computing still appears to be some way off, it's future is very exciting indeed. [7]

One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible their movement .

The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]

The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing.

The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]

The key breakthrough to arrive at this new idea to build qubits was to exploit the ability to control the nuclear spin of each atom. With that insight, the team has now conceived a unique way to use the nuclei as facilitators for the quantum logic operation between the electrons. [5]

Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions also.

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