Six-State Magnetic Memory

Computers are often described with "ones and zeros," referring to their binary nature: each memory element stores data in two states. But there is no fundamental reason why there should be just two. In a new study, researchers have designed a magnetic element that has six stable magnetic states, which paves the way toward realizing a six-state magnetic memory element. [13]

Quantum technology has the potential to revolutionize computation, cryptography, and simulation of quantum systems. However, quantum states are fragile, and so must be controlled without being measured. Researchers have now demonstrated a key property of Majorana zero modes that protects them from decoherence. The result lends positive support to the existence of Majorana modes, and goes further by showing that they are protected, as predicted theoretically. [11]

In what may provide a potential path to processing information in a quantum computer, researchers have switched an intrinsic property of electrons from an excited state to a relaxed state on demand using a device that served as a microwave "tuning fork." [10]

Optical photons would be ideal carriers to transfer quantum information over large distances. Researchers envisage a network where information is processed in certain nodes and transferred between them via photons. [9]

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 using Quantum Information.

In August 2013, the achievement of "fully deterministic" quantum teleportation, using a hybrid technique, was reported. On 29 May 2014, scientists announced a reliable way of transferring data by quantum teleportation. Quantum teleportation of data had been done before but with highly unreliable methods.

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 with the help of Quantum Information.

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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.

Researchers design six-state magnetic memory

Computers are often described with "ones and zeros," referring to their binary nature: each memory element stores data in two states. But there is no fundamental reason why there should be just two. In a new study, researchers have designed a magnetic element that has six stable magnetic states, which paves the way toward realizing a six-state magnetic memory element.

The researchers, Yevgeniy Telepinsky et al., from Bar-Ilan University in Israel and New York University in the US, have published a paper on the new magnetic structure in a recent issue of Applied Physics Letters.

This isn't the first time that researchers have designed memory cells with more than two states, or bits. The best-known example is multi-level flash memory cells, which can store up to four bits per cell. While multi-level flash cells have advantages such as a higher density and lower cost, they also suffer intrinsic drawbacks such as lower writing speeds and higher power consumption.

The new six-state memory element presented here is different because it is magnetic, whereas flash memory is electronic. Although electronic memories are currently the most commonly used type of memory, various types of magnetic random access memory (MRAM) are being actively researched due to advantages in low power consumption, fast operation, and long lifetime.

"Our proposal paves the way for enjoying the benefits of multi-level cells in MRAM, making it even more attractive for applications," Lior Klein, a physics professor at Bar-Ilan University and one of the study's lead authors, told Phys.org. "Furthermore, since MRAM is different in its nature from flash, there is no reason that it should suffer from the drawbacks of multi-level-cell flash memory."

Realizing the six-state magnetic element does not require any significant increase in complexity, such as adding layers, but rather involves simply structuring one of the magnetic layers differently—specifically, arranging the magnetic film into a pattern of three crossing ellipses. In the middle region where all three ellipses overlap, the researchers found that there are six different stable magnetic orientations. The orientations are parallel to the long axis of each ellipse, and can run in two opposite directions.

If such a pattern with six magnetic orientations can be controlled and incorporated in a magnetic memory element, then the number of memory states can be increased from two to six. The researchers showed that such control is possible by using a technique called spin-orbit torque switching, which uses spin-polarized electric current to switch between magnetic states. This demonstration shows that the spin-orbit torques can write data onto the magnetic structure, showing the potential for using the structure as a memory element.

The main advantage of having six states is that it would increase the memory density while avoiding the problems inherent in miniaturization. Currently the primary strategy for increasing memory density is to miniaturize each memory element so that more of them can fit on a chip. However, at these small scales, the memory elements are so close together that they begin to interfere with each other's states. The new design can avoid this problem, and also offers other advantages.

"Going from two to six states would triple the density under certain conditions (for example, maintaining the lateral scale of the bit)," Klein said. "In addition, other advantages are also expected. The cost of the memory would probably decrease significantly, and when such bits are incorporated in a magnetic memory array, we may witness other benefits such as increased reading speeds."

The researchers expect that it may be possible to design patterns with even more magnetic states. For example, their simulations show that a pattern of four crossing ellipses would yield a memory element with eight magnetic memory states.

"We intend to further increase the number of magnetic states and explore the limits of such an extrapolation," Klein said. "In addition, we would like to progress towards fabricating a prototype that will help us convince the magnetic memory industry to make a shift towards multi-level magnetic memory." [13]

Novel gate may enhance power of Majorana-based quantum computers

Quantum computers hold great potential, but they remain hard to build because their basic components—individual quantum systems like atoms, electrons or photons—are fragile. A relentless and noisy background constantly bombards the computer's data.

One promising theoretical approach, known as topological quantum computing, uses groups of special particles confined to a plane to combat this environmental onslaught. The particles, which arise only in carefully crafted materials, are held apart from each other so that the information they store is spread out in space. In this way, information is hidden from its noisy environment, which tends to disrupt small regions at a time. Such a computer would perform calculations by moving the particles around one another in a plane, creating intricate braids with the paths they trace in space and time.

Although evidence for these particles has been found in experiments, the most useful variety found so far appear only at the ends of tiny wires and cannot easily be braided around one another. Perhaps worse for the prospect of quantum computing is that these particles don't support the full power of a general quantum computer—even in theory.

Now, researchers at JQI and the Condensed Matter Theory Center (CMTC) at the University of Maryland, including JQI Fellows Sankar Das Sarma and Jay Deep Sau, have proposed a way to dispense with both of these problems. By adding an extra process beyond ordinary braiding, they discovered a way to give a certain breed of topological particles all the tools needed to run any quantum calculation, all while circumventing the need for actual braiding. The team described their proposal last month in Physical Review X (link is external).

The new proposal continues a line of research that began at JQI and CMTC in 2010. Two papers that year, co-authored by Das Sarma and Sau, were among the first to consider how to use Majorana fermions—exotic particles first theorized in 1937—as the foundation for a topological quantum computer. Those papers proposed both a platform for quantum computation using the particles and an experiment in which they might be found. Experimenters have since spotted signatures of the particles at the interfaces of certain materials—systems similar to those proposed by the JQI group.

Those interfaces are called upon again in the new work, which relies on the physics of a thin semiconductor wire placed atop a superconductor—a material that allows electrical currents to flow unhindered. The presence of the wire can change the quantum behavior of the superconductor in interesting ways.

"Normally, in superconductors, there is a barrier to having an odd number of electrons," says David Clarke, a postdoctoral researcher at CMTC and the first author of the paper. That's because in superconductors electrons are bound together in pairs. But, Clarke explains, adding a thin wire on top of a superconductor can create a refuge for single electrons. When a single electron occupies the wire, Majorana fermions are present at its two ends. And the presence or absence of the Majorana fermions stores one qubit—the fundamental memory unit of a quantum computer.

However, even if the Majorana fermions at the ends of wires were easy to braid around one another, they still would not support a universal quantum computer—a device capable of performing any quantum computation or simulating another quantum computer.

To get around this, Clarke and colleagues suggest using a quantum interaction between electronic charges and swirling vortices of magnetic fields that can be controllably introduced into the system. A phenomenon known as the Aharonov-Casher effect causes the quantum state of a charge—such as a Majorana fermion—to change when a magnetic vortex travels around it. Intriguingly, that modification is different if the vortex travels above the charge than if it travels below it.

In the paper, the team proposes a physical layout for using the effect in an experiment. As shown in the figure above, three superconductors—one with a semiconductor wire—surround a hole. In this empty region, the team imagines gently turning up a magnetic field. As the field increases, it draws in a single magnetic vortex, vacuuming it in through one of two junctions. Clarke says that he typically thinks of the vortices as coming from outside the superconductors, although their physical origin is in the junctions between superconducting islands.

Importantly, the process does not reveal which junction the vortex travels through. If it were possible to tell, the operation would not produce a useful quantum gate on the qubit stored in the wire. But because there is no way to tell which path it takes to enter the empty region, it must be treated as a quantum particle with a probability to take each. This quantum motion results in an interference between the two paths and produces a useful logic gate on the Majorana qubit.

The new gate—the details of which experimenters would tune by adjusting electrical controls—can be combined with those generated by braiding Majorana zero mode particles to do any arbitrary quantum calculation. The paper discusses how the proposal could be scaled up to include many qubits and even how to perform quantum computations in this system without actually doing any braiding. This relies on a "measurement-only" approach in which particles are swapped and braided by making sequences of measurements on neighboring qubits.

The team also notes that their method of gently turning up a magnetic field doesn't depend on the precise timing of any electrical signal, a feature that makes it immune to errors that afflict other proposals based on Majorana zero modes.

The team singles out one milestone as a first test of whether their technique works: creating verifiable entanglement between two qubits. "The ability to perform these non-braiding gates is necessary to allow quantum computation," says Clarke. "The test we propose goes a step further, and would show that the gate that has been produced is also sufficient for quantum computation, given braiding and measurement." [12]

Protected Majorana states for quantum information

Quantum technology has the potential to revolutionize computation, cryptography, and simulation of quantum systems. However, quantum physics places a new demand on information processing hardware: quantum states are fragile, and so must be controlled without being measured. Researchers at the Niels Bohr Institute have now demonstrated a key property of Majorana zero modes that protects them from decoherence. The result lends positive support to the existence of

Majorana modes, and goes further by showing that they are protected, as predicted theoretically. The results have been published in the scientific magazine, Nature.

Normal computers are limited in their ability to solve certain classes of problems. The limitation lies in the fact that the operation of a conventional computers is based on classical states, or bits, the fundamental unit of information that is either 0 or 1.

In a quantum computer, data is stored in quantum bits, or qubits. According to the laws of quantum mechanics, a qubit can be in a superposition of states -- a 0 and 1 at the same time. By taking advantage of this and other properties of quantum physics, a quantum computer made of interconnected qubits should be able to tackle certain problems much more efficiently than would be possible on a classical computer.

There are many different physical systems that could in principle be used as quantum bits. The problem is that most quantum systems lose coherence very quickly--the qubit becomes a regular bit once measured. This is why researchers are still searching for the best implementation of quantum hardware. Enter the Majorana zero mode, a delocalized state in a superconductor that resists decoherence by sharing quantum information between separated locations. In a Majorana mode, the information is stored in such a way that a disturbance of either location leaves the quantum information intact.

"We are investigating a new kind of particle, called a Majorana zero mode, which can provide a basis for quantum information that is protected against measurement by a special and who knows, perhaps unique property of these particles. Majorana particles don't exist as particles on their own, but they can be created using a combination of materials involving superconductors and semiconductors. What we find is that, first of all, the Majorana modes are present, verifying previous experiments, but more importantly that they are protected, just as theory predicts," says Villum Kann Rasmussen Professor Charles Marcus, Director of the Center for Quantum Devices (QDev) and Station Q Copenhagen, at the Niels Bohr Institute, University of Copenhagen.

Nanowires for quantum technology

The Center for Quantum Devices is a leading research center in quantum information technology -- with activities in theory, experiment, and materials research.

Semiconductor nanowires around 10 micrometers long and around 0.1 micrometers in diameter, coated with superconducting aluminum were used to form isolated islands of various lengths. By applying a strong magnetic field along the axis of the wire, and cooling the wires to below a tenth of a kelvin, a new kind of superconducting state, called a topological superconductor, was formed.

Quantum states are protected

In 2012, physicists at Delft University in the Netherlands found the first signatures of Majorana zero modes in a similar system, with further evidence revealed in subsequent experiments around the world. Now, researchers at the Center for Quantum Devices have demonstrated critical predictions regarding their behavior, namely that their quantum states are protected in a fundamentally different manner from conventional quantum states.

The experiments were carried out by PhD Candidate Sven Albrecht and postdoc Andrew Higginbotham, now at the University of Colorado/NIST, USA, using new superconductor-semiconductor hybrid nanowires developed by Assistant Professor Peter Krogstrup in collaboration with Marcus and Professor Jesper Nygard.

"The protection is related to the exotic property of the Majorana mode that it simultaneously exists on both ends of the nanowire, but not in the middle. To destroy its quantum state, you have to act on both ends at the same time, which is unlikely," says Sven Albrecht.

Albrecht explains that it was a challenging effort to demonstrate the protection experimentally. The researchers had to repeat their experiment many times with nanowires of different lengths in order to show that the protection improved with wire length.

"Exponential protection is an important check as we continue our basic exploration, and ultimately application, of topological states of matter. Two things have pushed the field forward--from the first Majorana sightings at Delft to the present results--the first is strong interaction between theory and experiment. The second is remarkable materials development in Copenhagen, an effort that predates our Center. Without these new materials, the field was rather stuck. That's behind us now." says Charles Marcus.

The research at the Center for Quantum Devices and Station Q Copenhagen was supported by Microsoft Research and the Danish National Research Foundation and the Villum Foundation. [11]

A new spin on quantum computing: Scientists train electrons with microwaves

The team's findings could also lead to enhancements in magnetic resonance techniques, which are widely used to explore the structure of materials and biomolecules, and for medical imaging.

The international research team, which included scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), demonstrated how to dramatically increase the coupling of microwaves in a specially designed superconducting cavity to a fundamental electron property called spin—which, like a coin, can be flipped.

By zapping an exotic silicon material developed at Berkeley Lab with the microwaves, they found that they could rapidly change the electron spins from an excited state to a relaxed, ground state by causing the electrons to emit some of their energy in the form of microwave particles known as photons.

Left on their own, the electron spins would be extremely unlikely to flip back to a relaxed state and to also emit a photon - the natural rate for this light-emitting effect, known as the Purcell effect, is about once every 10,000 years. The experiment demonstrated an accelerated, controllable relaxation of electron spins and the release of a microwave photon in about 1 second, said Thomas Schenkel, a physicist in Berkeley Lab's Accelerator Technology and Applied Physics Division who led the design and development of the silicon-bismuth sample used in the experiment.

A new spin on quantum computing: Scientists train electrons with microwaves

Like the classical tuning fork slung from guitar strings in this photo, scientists used a device that worked like a microwave tuning fork to switch a fundamental property of electrons on demand in a silicon-bismuth sample developed at Berkeley Lab. Credit: Flickr/Pierre Guinoiseau

"It's like a juggler who throws the balls up, and the balls come down 1,000 times faster than normal, and they also emit a microwave flash as they drop," he said. The results were published online Feb. 15 in the journal Nature.

"Our results are highly significant for quantum information processing," said Patrice Bertet, a quantum electronics scientist at the French Atomic Energy Commission (CEA) who led the experiment. "Indeed, they are a first step toward the strong coupling of individual electron spins to microwave photons, which could form the basis of a new spin-based quantum computer architecture."

John Morton, a professor at the London Center for Nanotechnology and co-author of the study, said, "Our ultimate aim is to find a link between quantum information that is fixed and quantum information that can be transported by photons."

In today's computers, information is stored as individual bits, and each bit can either be a one or a zero. Quantum computers, though, could conceivably be exponentially more powerful than modern computers because they would use a different kind of bit, called a qubit, that because of the weird ways of quantum mechanics can simultaneously behave as both a one and a zero.

A coupled array of qubits would allow a quantum computer to perform many, many calculations at the same time, and electron spins are candidates for qubits in a quantum computer. The latest study shows how the microwave photons could work in concert with the spins of electrons to move information in a new type of computer.

"What we need now is ways to wire up these systems—to couple these spins together," Morton said. "We need to make coupled qubits that can perform computations."

In the experiment, conducted at CEA in France, a small sample of a highly purified form of silicon was implanted with a matrix of bismuth atoms, and a superconducting aluminum circuit was deposited on top to create a high-quality resonant cavity that allowed precise tuning of the microwaves. The electron spins of the bismuth atoms were then flipped into the excited, "spin-up" state.

The microwave cavity was then tuned, like a musical tuning fork, to a particular resonance that coaxed the spins into emitting a photon as they flipped back to a relaxed state. The cavity boosted the number of states into which a photon can be emitted, which greatly increased the decay rate for the electron spins in a controllable way. The technique is much like buying more lottery tickets to increase your chances of winning, Morton said.

A new spin on quantum computing: Scientists train electrons with microwaves

From left are, Berkeley Lab scientists Thomas Schenkel, Qing Ji and Peter Seidl at the NDCX-II (Neutralized Drift Compression Experiment II), which produces powerful ion beams. Researchers are exploring how to use NDCX-II to process exotic …more

The large bismuth atoms embedded in the silicon sample provided the electrons with unique spin properties that enabled the experiment. Schenkel said that implanting the bismuth atoms into the delicate silicon framework, a process known as "doping," was "like squeezing bowling balls into a lattice of ping-pong balls."

"We did a new trick with silicon. People wouldn't expect you could squeeze anything new out of silicon," Schenkel said. "Now we're looking into further improving bismuth-doped silicon and into tailoring the spin properties of other materials, and using this experimental technique for these materials."

To enhance the performance of materials used in future experiments, Schenkel said it will be necessary to improve the doping process so it is less damaging to the silicon lattice. Also, the implantation process could be designed to produce regularly spaced arrays of individual electron spins that would be more useful for quantum computing than a concentrated ensemble of electron spins.

"We are now doing experiments on processing this and other materials at higher temperature and pressure with nanosecond ion pulses at NDCX-II, one of the accelerators here at Berkeley Lab," Schenkel said. "There are indications that it will improve the overall spin quality."

Researchers said the latest research could potentially prove useful in boosting the sensitivity of scientific techniques like nuclear magnetic resonance spectroscopy and dynamic nuclear polarization, useful for a range of experiments, and could also shorten experimental times by manipulating spin properties.

"You need a way to reset spins—the ability to cause them to relax on demand to improve the rate at which you can repeat an experiment," Morton said.

Bertet said it may be possible to further accelerate the electron-flipping behavior to below 1 millisecond, compared to the 1-second rate in the latest results.

"This will then open the way to many new applications," he said. [10]

How to Win at Bridge Using Quantum Physics

Contract bridge is the chess of card games. You might know it as some stuffy old game your grandparents play, but it requires major brainpower, and preferably an obsession with rules and strategy. So how to make it even geekier? Throw in some quantum mechanics to try to gain a competitive advantage. The idea here is to use the quantum magic of entangled photons–which are essentially twins, sharing every property–to transmit two bits of information to your bridge partner for the price of one. Understanding how to do this is not an easy task, but it will help elucidate some basic building blocks of quantum information theory. It's also kind of fun to consider whether or not such tactics could ever be allowed in professional sports. [6]

Quantum Information

In quantum mechanics, quantum information is physical information that is held in the "state" of a quantum system. The most popular unit of quantum information is the qubit, a two-level quantum system. However, unlike classical digital states (which are discrete), a two-state quantum system can actually be in a superposition of the two states at any given time.

Quantum information differs from classical information in several respects, among which we note the following:

However, despite this, the amount of information that can be retrieved in a single qubit is equal to one bit. It is in the processing of information (quantum computation) that a difference occurs.

The ability to manipulate quantum information enables us to perform tasks that would be unachievable in a classical context, such as unconditionally secure transmission of information. Quantum information processing is the most general field that is concerned with quantum information. There are certain tasks which classical computers cannot perform "efficiently" (that is, in polynomial time) according to any known algorithm. However, a quantum computer can compute the answer to some of these problems in polynomial time; one well-known example of this is Shor's factoring algorithm. Other algorithms can speed up a task less dramatically - for example, Grover's search algorithm which gives a quadratic speed-up over the best possible classical algorithm.

Quantum information, and changes in quantum information, can be quantitatively measured by using an analogue of Shannon entropy. Given a statistical ensemble of quantum mechanical systems with the density matrix S, it is given by.

Many of the same entropy measures in classical information theory can also be generalized to the quantum case, such as the conditional quantum entropy. [7]

Heralded Qubit Transfer

Optical photons would be ideal carriers to transfer quantum information over large distances. Researchers envisage a network where information is processed in certain nodes and transferred between them via photons. However, inherent losses in long-distance networks mean that the information transfer is subject to probabilistic errors, making it hard to know whether the transfer of a qubit of information has been successful. Now Gerhard Rempe and colleagues from the Max Planck Institute for Quantum Optics in Germany have developed a new protocol that solves this problem through a strategy that "heralds" the accurate transfer of quantum information at a network node.

The method developed by the researchers involves transferring a photonic qubit to an atomic qubit trapped inside an optical cavity. The photon-atom quantum information transfer is initiated via a quantum “logic-gate” operation, performed by reflecting the photon from the atom-cavity system, which creates an entangled atom-photon state. The detection of the reflected photon then collapses the atom into a definite state. This state can be one of two possibilities, depending on the photonic state detected: Either the atom is in the initial qubit state encoded in the photon and the transfer process is complete, or the atom is in a rotated version of this state. The authors were able to show that the roles of the atom and photon could be reversed. Their method could thus be used as a quantum memory that stores (photon-to-atom state transfer) and recreates (atom-to-photon state transfer) a single-photon polarization qubit. [9]

Quantum Teleportation

Quantum teleportation is a process by which quantum information (e.g. the exact state of an atom or photon) can be transmitted (exactly, in principle) from one location to another, with the help of classical communication and previously shared quantum entanglement between the sending and receiving location. Because it depends on classical communication, which can proceed no faster than the speed of light, it cannot be used for superluminal transport or communication of classical bits. It also cannot be used to make copies of a system, as this violates the no-cloning theorem. Although the name is inspired by the teleportation commonly used in fiction, current technology provides no possibility of anything resembling the fictional form of teleportation. While it is possible to teleport one or more qubits of information between two (entangled) atoms, this has not yet been achieved between molecules or anything larger. One may think of teleportation either as a kind of transportation, or as a kind of communication; it provides a way of transporting a qubit from one location to another, without having to move a physical particle along with it.

The seminal paper first expounding the idea was published by C. H. Bennett, G. Brassard, C. Crépeau, R. Jozsa, A. Peres and W. K. Wootters in 1993. Since then, quantum teleportation has been realized in various physical systems. Presently, the record distance for quantum teleportation is 143 km (89 mi) with photons, and 21 m with material systems. In August 2013, the achievement of "fully deterministic" quantum teleportation, using a hybrid technique, was reported. On 29 May 2014, scientists announced a reliable way of transferring data by quantum teleportation. Quantum teleportation of data had been done before but with highly unreliable methods. [8]

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]

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 dp impulse difference and a dx 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 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ 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 ½ 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 then 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 ν 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_o 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 Bing 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 rate Mp=1840 Me. 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

The method developed by the researchers involves transferring a photonic qubit to an atomic qubit trapped inside an optical cavity. The photon-atom quantum information transfer is initiated via a quantum “logic-gate” operation, performed by reflecting the photon from the atom-cavity system, which creates an entangled atom-photon state. [9]

In August 2013, the achievement of "fully deterministic" quantum teleportation, using a hybrid technique, was reported. On 29 May 2014, scientists announced a reliable way of transferring data by quantum teleportation. Quantum teleportation of data had been done before but with highly unreliable methods. [8]

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 they 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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