Controlling Quantum Systems

Researchers from the Department of Applied Mathematics and the Institute for Quantum Computing at the University of Waterloo have developed a versatile new way of controlling quantum systems that can affect the reliability of experiments. [14]

A team around Dr. Stephan Dürr from the Quantum Dynamics Division of Prof. Gerhard Rempe at the Max Planck Institute of Quantum Optics has now demonstrated in an experiment how an important gate operation – the exchange of the binary bit values 0 and 1 – can be realized with single photons. [13]

A curious type of nonlocal phenomenon known as one-way quantum steering has been demonstrated experimentally for the first time by two independent groups of physicists. This phenomenon is similar to quantum entanglement but applies when one of the two parties sharing a quantum state does not trust the source of quantum particles. The researchers say their work could help to broaden applications of quantum cryptography. [12]

Researchers at the Institute of Quantum Optics and Quantum Information, the University of Vienna, and the Universitat Autonoma de Barcelona have achieved a new milestone in quantum physics: they were able to entangle three particles of light in a high-dimensional quantum property related to the 'twist' of their wavefront structure. The results from their experiment appear in the journal Nature Photonics. [11]

Quantum cryptography involves two parties sharing a secret key that is created using the states of quantum particles such as photons. The communicating parties can then exchange messages by conventional means, in principle with complete security, by encrypting them using the secret key. Any eavesdropper trying to intercept the key automatically reveals their presence by destroying the quantum states. [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.

Contents

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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 find new way to control quantum systems

Researchers from the Department of Applied Mathematics and the Institute for Quantum Computing at the University of Waterloo have developed a versatile new way of controlling quantum systems that can affect the reliability of experiments.

To develop quantum technologies, it is critical to first build capabilities to control extraordinarily fragile quantum systems. The team from Waterloo found a way to control a quantum system without exposing it to vibration or other interference.

The new technique was published in Physical Review A.

"The idea is to avoid interacting with a quantum system directly," said David Layden, a master's student in the Faculty of Mathematics at Waterloo and lead author of the paper. "Instead, you introduce a second, so-called auxiliary quantum system, such as an atom, for example. You then manipulate it and use it to indirectly affect, and ultimately control, the main system."

Researchers have already used indirect approaches to manipulating quantum systems in several different experiments. But the techniques they used differed based on the particular laboratory setup involved. Each new type of experiment required a different technique.

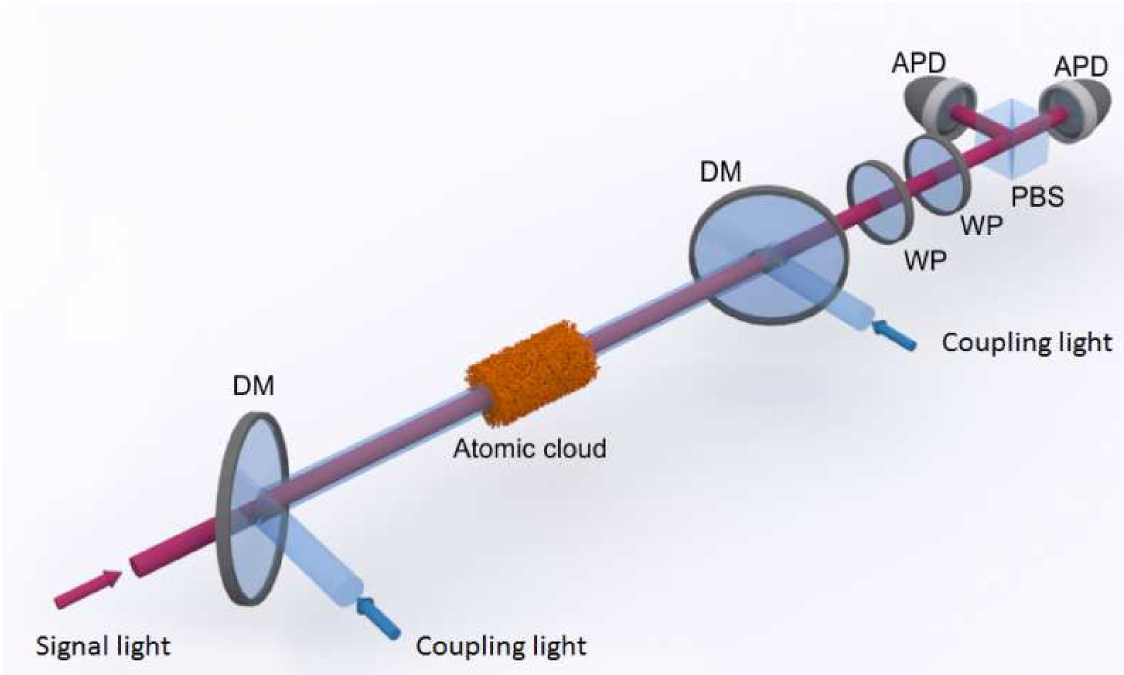
Now, the Waterloo researchers' one-size-fits-all method of indirectly controlling quantum systems is applicable to any experiment. It involves soft, frequent touches to the main system from the auxiliary one, which allow researchers to freely steer a quantum system while keeping its quantum nature intact.

"These touches are strong enough to fully control the target quantum systems, but short enough to avoid destroying their quantum properties," said Professor Eduardo Martin-Martinez, of both the Department of Applied Mathematics and Institute for Quantum Computing at Waterloo, and a co-author of this work.

"To achieve this level of control, we must use an auxiliary system that also possesses quantum properties," said Professor Achim Kempf, University Research Chair in the Department of Applied Mathematics at Waterloo, and co-author of the study.

The new technique could play an important role in a number of quantum technologies, which in turn, promise to impact a wide range of fields, from high performance computing to pharmaceutical drug discovery. [14]

Quantum logical operations realized with single photons



A cloud of cold atoms is illuminated with red signal light and blue coupling light. The light pulses are superimposed on dichroic mirrors (DM). With wave plates (WP), a polarizing beam splitter (PBS), and avalanche photodiodes (APD) the polarization of the transmitted signal light is determined.

Scientists from all over the world are working on concepts for future quantum computers and their experimental realization. Commonly, a typical quantum computer is considered to be based on a network of quantum particles that serve for storing, encoding and processing quantum information. In analogy to the case of a classical computer a quantum logic gate that assigns output signals to input signals in a deterministic way would be an essential building block. A team around Dr. Stephan Dürr from the Quantum Dynamics Division of Prof. Gerhard Rempe at the Max Planck Institute of Quantum Optics has now demonstrated in an experiment how an important gate operation – the exchange of the binary bit values 0 and 1 – can be realized with single photons. A first light pulse containing one photon only is stored as an excitation in an ultracold cloud of about 100 000 rubidium atoms. This gives rise to the effect that a second light pulse that passes through the cloud exhibits a phase shift of 180 degrees.

"Photons are ideal carriers of quantum information because they hardly interact with their environment and can easily be transmitted over long distances," explains Dr. Stephan Dürr, leader of the project. "Therefore we are very interested in the development of a photon-photon-quantum gate where a single light pulse can modify an incoming photonic qubit in a deterministic way."

Modern data processing is based on the principle that information can be encoded in a binary system. In this context, logic gates fulfil the task of implementing truth tables which uniquely assign a specific output pattern to a given input signal. For instance an input value of 0 can be transformed into an output value of 1 or vice versa. In a photon-photon-quantum gate, this corresponds to the process of a single photon manipulating the state of a second single photon in a deterministic way.

This interaction has to be mediated by matter. Up to now no physical system could be found to provide a sufficiently strong interaction.

In this experiment a cloud of about 100 000 rubidium atoms is cooled down to a temperature of 0.5 microkelvin and caught in a dipole trap composed of several light fields. Next, a rapid sequence of three light pulses impinges onto the cloud: the first so-called control pulse determines whether the second target pulse is significantly modified when it passes through the cloud, i.e. whether the gate operation is switched on or off. A third pulse is used to retrieve an excitation that has potentially been stored.

The light pulses consist of two components: on the one hand, they contain red signal light so weak that a light pulse carries only one photon on average. With a wavelength of 780 nm it is near-resonant with a certain atomic transition. Without further treatment the light pulse would pass through the atomic cloud and acquire a certain phase shift. However, by adding blue coupling light of high intensity with a wavelength of 480 nm the photon in the signal pulse can be stored in a controlled and reversible way. During this process, one atom in the cloud is transferred into a highly excited Rydberg state where one electron is located at a large distance from the nucleus.

In the next step, the atoms are irradiated with the target pulse which is also composed of both signal and coupling light. As the Rydberg atom exhibits a long-range van der Waals interaction with the other atoms in the cloud, atomic energy levels inside a certain region around the Rydberg atom are shifted. This results in a larger detuning of the target pulse from the atomic levels compared to the case without a previously stored control pulse.

Because of this detuning the target pulse picks up a phase shift that differs by 180 degrees from the phase shift obtained when no control excitation is stored. "It is this additional phase shift, caused by the van der Waals interaction, that really matters," says Dr. Dürr. "This makes it possible to generate quantum states that are orthogonal to each other, which corresponds to a bit flip from 0 to 1." In the last step, a coupling light pulse retrieves the signal photon that is stored in the cloud.

In a series of measurements, using wave plates and a polarizing beam splitter the scientists determined the polarization of both red signal photons after passing through the atomic cloud. Thereby they were able to show that the light pulse had picked up an additional phase shift of 180 degrees whenever the signal laser was switched on during the control pulse. The whole cycle – the storage of the control pulse, the propagation of the target pulse and the retrieval of the control excitation – takes only a few microseconds.

"The experiment demonstrates that we can rotate the polarization plane of the photonic qubit in the target pulse with just one control photon," resumes Dr. Dürr. "This is an important prerequisite for the realization of a quantum gate. However, a quantum gate also has to provide the possibility to generate an entangled final state from two separate initial states. To achieve this goal we are planning to do further experiments." [13]

Why quantum cryptography could be a one-way street

A curious type of nonlocal phenomenon known as one-way quantum steering has been demonstrated experimentally for the first time by two independent groups of physicists. This phenomenon is similar to quantum entanglement but applies when one of the two parties sharing a quantum state does not trust the source of quantum particles. The researchers say their work could help to broaden applications of quantum cryptography.

The idea of quantum nonlocality was first discussed in a famous paper published by Albert Einstein, Boris Podolsky and Nathan Rosen in 1935. The trio described a thought experiment designed to illustrate the inadequacies of Niels Bohr's interpretation of quantum mechanics, in which an object being measured and the measuring device are regarded as one inseparable whole. Einstein, Podolsky and Rosen argued that either information could travel instantaneously between two points (so apparently contradicting special relativity) or quantum theory was incomplete; in other words, "hidden variables" were needed in addition to the wavefunction to describe physical reality.

As it turned out, Bohr was vindicated. Physicists have gone on to acquire compelling, if not completely watertight, evidence for nonlocality, and have exploited the phenomenon in quantum-communications technology. The most familiar example is quantum entanglement, put forward by Erwin Schrödinger in response to the paper by Einstein and colleagues, in which pairs of quantum particles can be prepared such that even when placed a long way away from each other, a measurement on one of them instantaneously fixes the state of the other. However, there are other forms of nonlocality, including the stronger Bell nonlocality, discovered by the Northern-Irish physicist John Bell, which is inconsistent with the theory of local hidden variables.

Halfway house

In a sense, quantum steering, introduced by Schrödinger, is a halfway house between these other two forms of nonlocality. The two parties involved in a quantum transaction, known traditionally as Alice and Bob, both trust the source of quantum particles when it comes to entangling pairs of those particles. For Bell nonlocality, meanwhile, neither of them trusts the source. But when they do quantum steering, only one of them, let's say Bob, trusts the source. In this way, Alice can "steer" the state of the particles observed by Bob, which means that measurements she carries out on her half of the entangled particle pairs affect Bob's state in a way that cannot be explained classically.

If the quantum states employed in steering are symmetrical, then Alice and Bob can steer each other. However, if the states are asymmetrical, then Alice and Bob will not steer one another to the same degree. Indeed, there are some states for which Alice (for example) can steer Bob but not the other way round. This is known as one-way quantum steering.

In 2012 Roman Schnabel and colleagues at the University of Hannover in Germany observed this kind of steering, but they did so only in a limited context – for "Gaussian" measurements carried out on "Gaussian" states. The latest research, in contrast, was designed to demonstrate one-way steering of a given type of state, regardless of the measurements carried out on it.

Tricky problem

The two experiments use similar apparatus to create quantum states from entangled pairs of photons, but they test steering in different ways. Specifically, they take different approaches to the tricky problem of verifying that Bob cannot steer Alice (in addition to showing that Alice can steer Bob). This involves showing that no matter what Bob does to his state, he can never alter Alice's state in a way that could not be achieved classically. Chuan-Feng Li of the University of Science and Technology of China in Hefei and colleagues did so by specifying that Bob can only ever perform two distinct measurements, while Geoff Pryde and co-workers at Griffith University in Brisbane, Australia, were able to do so for any arbitrary number of measurements.

Li says that one-way steering could find practical applications in asymmetric quantum information. For example, he says, it could be applied to one-way quantum key distribution, which involves creating a secret key that can be used to encrypt and decrypt messages by encoding weak laser pulses in time. This would allow cryptography even if one of the two communicating parties does not trust their measurement device.

Elegant and convincing

Nicolas Brunner of the University of Geneva, whose group last year set out the theory of one-way quantum steering, praises the Chinese and Australian groups for their "elegant and convincing experimental demonstration" of one-way steering. He says that applications of the work "can be envisaged" but believes that a "killer application" still has to be found.

Schnabel agrees that applications are still probably some way off. "For steering in quantum information, it is usually enough to define steering in the desired direction [i.e. Alice to Bob]," he says.

The research is reported in two papers published in Physical Review Letters. [12]

Three 'twisted' photons in 3 dimensions

Entanglement is a counterintuitive property of quantum physics that has long puzzled scientists and philosophers alike. Entangled quanta of light seem to exert an influence on each other, irrespective of how much distance is between them. Consider for example a metaphorical quantum ice dancer, who has the uncanny ability to pirouette both clockwise and counter-clockwise simultaneously. A pair of entangled ice-dancers whirling away from each other would then have perfectly correlated directions of rotation: If the first dancer twirls clockwise then so does her partner, even if skating in ice rinks on two different continents. "The entangled photons in our experiment can be illustrated by not two, but three such ice dancers, dancing a perfectly synchronized quantum mechanical ballet," explains Mehul Malik, the first author of the paper. "Their dance is also a bit more complex, with two of the dancers performing yet another correlated movement in addition to pirouetting. This type of asymmetric quantum entanglement has been predicted before on paper, but we are the first to actually create it in the lab."

From fundamentals to applications: Layered quantum cryptography

The scientists created their three-photon entangled state by using yet another quantum mechanical trick: they combined two pairs of high-dimensionally entangled photons in such a manner that it became impossible to ascertain where a particular photon came from. Besides serving as a test bed for studying many fundamental concepts in quantum mechanics, multi-photon entangled states such as these have applications ranging from quantum computing to quantum encryption. Along these lines, the authors of this study have developed a new type of quantum cryptographic protocol using their state that allows different layers of information to be shared asymmetrically among multiple parties with unconditional security. "The experiment opens the door for a future quantum Internet with more than two partners and it allows them to communicate more than one bit per photon," says Anton Zeilinger. Many technical challenges remain before such a quantum communication protocol becomes a practical reality. However, given the rapid progress in quantum technologies today, it is only a matter of time before this type of entanglement finds a place in the quantum networks of the future. [11]

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 cryptography set for lift-off

Exchanging messages with almost complete security by exploiting the strange laws of quantum mechanics should in future be possible on a global scale. That is the conclusion of physicists in Italy, who have found that the delicate states needed for quantum cryptography can be transmitted via laser beam from an orbiting satellite to a receiver on the surface of the Earth. The researchers say that the relatively simple technology needed for such encryption could be incorporated into conventional communications satellites.

Quantum cryptography involves two parties sharing a secret key that is created using the states of quantum particles such as photons. The communicating parties can then exchange messages by conventional means, in principle with complete security, by encrypting them using the secret key. Any eavesdropper trying to intercept the key automatically reveals their presence by destroying the quantum states.

Losses and curvature

Such cryptographic systems are already produced commercially, but they use fibre-optic cables. Losses in the cables limit the distance over which quantum keys can be sent to about 100 km, and that distance cannot be increased using repeaters, as is the case with classical data, because it is impossible to carry out the necessary amplification. Alternatively, quantum bits, or qubits, can be transmitted through the atmosphere, but this approach has a similar distance limit imposed by the curvature of the Earth.

This is where satellites could help. A single satellite, for example, could be used to send quantum data to two people on the Earth's surface to enable those people to share a secret key. To date, however, no device capable of generating or detecting quantum states – such as single photons – has been placed in orbit.

Paolo Villoresi of the University of Padua and colleagues have taken a creative approach to this problem by using the Matera Laser Ranging Observatory in southern Italy. This facility usually directs laser pulses at passing satellites and then measures the reflected pulses in order to measure tiny variations in the Earth's gravitational field. In 2008 Villoresi's team worked with a group of physicists at the University of Vienna to bounce very weak laser pulses from a satellite and then show that less than one photon per pulse could be detected on the ground (see "Single photons make the trek from space").

Polarization is preserved

In this latest research, the Italian group has gone one better, showing that it is possible to preserve the polarization state of those photons. Doing so is essential to quantum cryptography because it is the property of polarization – the orientation of a wave's oscillation – that is used to define the value of the qubits that make up a quantum key.

The researchers prepared the observatory's laser photons in one of four polarization states – horizontal, vertical, left-circular or right-circular – and beamed each of the states in 10-second bursts towards five satellites (including NASA's Jason-2) in orbits up to 2000 km above the Earth's surface. Their aim was to establish whether or not they could limit the fraction of qubits in each burst that had the wrong polarization after reflection to less than 11%. Above this figure, information theory dictates that no secret key can be established.

Villoresi and colleagues found, as hoped, that the error rates from four of the satellites were in single-figure percentages. These satellites employ corner-cube retroreflectors with metallic coatings, which are needed to preserve polarization states. The fifth satellite has uncoated retroreflectors and generated error rates of about 40%.

"Our results prove that quantum-key distribution from an orbiting terminal and a base station is not only a promising idea but nowadays is realizable," the researchers write.

Rotation on the fly

The tests did not involve the satellites transmitting qubits that could be used to make actual quantum keys, since the polarizations of the qubits were determined on the ground. But the researchers say that a straightforward modification of existing retroreflectors could make quantum-key generation a reality. All that is needed, they say, is to add a device known as a Faraday rotator and a random-number generator to each retroreflector in order to rotate the polarization of incoming photons on the fly.

Scientists in China have already developed a satellite that will generate quantum keys, and plan to launch it next year. This mission will create entangled pairs of photons in space and then send the two halves of each pair simultaneously to two communicating parties on the ground. The retroreflector-based scheme, on the other hand, involves transmitting the key to each user separately. According to Villoresi, the latter approach will be much cheaper and easier to implement and, he says, could "piggyback" on satellites due to be launched anyway. [10]

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.

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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 tests did not involve the satellites transmitting qubits that could be used to make actual quantum keys, since the polarizations of the qubits were determined on the ground. But the researchers say that a straightforward modification of existing retroreflectors could make quantum-key generation a reality. All that is needed, they say, is to add a device known as a Faraday rotator and a random-number generator to each retroreflector in order to rotate the polarization of incoming photons on the fly. [10]
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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