Electron-Photon Small-Talk

A Princeton University-led team has built a device that advances silicon-based quantum computers, which when built will be able to solve problems beyond the capabilities of everyday computers. The device isolates an electron so that can pass its quantum information to a photon, which can then act as a messenger to carry the information to other electrons to form the circuits of the computer. [19]

Intricately shaped pulses of light pave a speedway for the accelerated dynamics of quantum particles, enabling faster switching of a quantum bit. [18]

An international team of scientists has succeeded in making further improvements to the lifetime of superconducting quantum circuits. [17]

A Yale-led group of researchers has derived a formula for understanding where quantum objects land when they are transmitted. [16]

The scheme is based on the ideas of physicist David J. Thouless, who won half the 2016 Nobel Prize in physics for his work on topological effects in materials. Topological effects are to do with geometry, and their use in quantum computing can help protect fragile quantum states during processing. [15]

Now a researcher and his team at Tyndall National Institute in Cork have made a 'quantum leap' by developing a technical step that could enable the use of quantum computers sooner than expected. [14]

A method to produce significant amounts of semiconducting nanoparticles for light-emitting displays, sensors, solar panels and biomedical applications has gained momentum with a demonstration by researchers at the Department of Energy's Oak Ridge National Laboratory. [13]

A source of single photons that meets three important criteria for use in quantum-information systems has been unveiled in China by an international team of physicists. Based on a quantum dot, the device is an efficient source of photons that emerge as solo particles that are indistinguishable from each other. The researchers are now trying to use the source to create a quantum computer based on "boson sampling". [11]

With the help of a semiconductor quantum dot, physicists at the University of Basel have developed a new type of light source that emits single photons. For the first time, the researchers have managed to create a stream of identical photons. [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.

Electron-photon small-talk could have big impact on quantum computing

A Princeton University-led team has built a device that advances silicon-based quantum computers, which when built will be able to solve problems beyond the capabilities of everyday computers. The device isolates an electron so that can pass its quantum information to a photon, which can then act as a messenger to carry the information to other electrons to form the circuits of the computer.

In a step that brings silicon-based quantum computers closer to reality, researchers at Princeton University have built a device in which a single electron can pass its quantum information to a particle of light. The particle of light, or photon, can then act as a messenger to carry the information to other electrons, creating connections that form the circuits of a quantum computer.

The research, published in the journal Science and conducted at Princeton and HRL Laboratories in Malibu, California, represents a more than five-year effort to build a robust capability for an electron to talk to a photon, said Jason Petta, a Princeton professor of physics.

"Just like in human interactions, to have good communication a number of things need to work out—it helps to speak the same language and so forth," Petta said. "We are able to bring the energy of the electronic state into resonance with the light particle, so that the two can talk to each other."

The discovery will help the researchers use light to link individual electrons, which act as the bits, or smallest units of data, in a quantum computer. Quantum computers are advanced devices that, when realized, will be able to perform advanced calculations using tiny particles such as electrons, which follow quantum rules rather than the physical laws of the everyday world.

Each bit in an everyday computer can have a value of a 0 or a 1. Quantum bits—known as qubits—can be in a state of 0, 1, or both a 0 and a 1 simultaneously. This superposition, as it is known, enables quantum computers to tackle complex questions that today's computers cannot solve.

Simple quantum computers have already been made using trapped ions and superconductors, but technical challenges have slowed the development of silicon-based quantum devices. Silicon is a highly attractive material because it is inexpensive and is already widely used in today's smartphones and computers.

The researchers trapped both an electron and a photon in the device, then adjusted the energy of the electron in such a way that the quantum information could transfer to the photon. This coupling enables the photon to carry the information from one qubit to another located up to a centimeter away.

Quantum information is extremely fragile—it can be lost entirely due to the slightest disturbance from the environment. Photons are more robust against disruption and can potentially carry quantum information not just from qubit to qubit in a quantum computer circuit but also between quantum chips via cables.

For these two very different types of particles to talk to each other, however, researchers had to build a device that provided the right environment. First, Peter Deelman at HRL Laboratories, a corporate research-and-development laboratory owned by the Boeing Company and General Motors, fabricated the semiconductor chip from layers of silicon and silicon-germanium. This structure trapped a single layer of electrons below the surface of the chip. Next, researchers at Princeton laid tiny wires, each just a fraction of the width of a human hair, across the top of the device. These nanometer-sized wires allowed the researchers to deliver voltages that created an energy landscape capable of trapping a single electron, confining it in a region of the silicon called a double quantum dot.

The researchers used those same wires to adjust the energy level of the trapped electron to match that of the photon, which is trapped in a superconducting cavity that is fabricated on top of the silicon wafer.

Prior to this discovery, semiconductor qubits could only be coupled to neighboring qubits. By using light to couple qubits, it may be feasible to pass information between qubits at opposite ends of a chip.

The electron's quantum information consists of nothing more than the location of the electron in one of two energy pockets in the double quantum dot. The electron can occupy one or the other pocket, or both simultaneously. By controlling the voltages applied to the device, the researchers can control which pocket the electron occupies.

"We now have the ability to actually transmit the quantum state to a photon confined in the cavity," said Xiao Mi, a graduate student in Princeton's Department of Physics and first author on the paper. "This has never been done before in a semiconductor device because the quantum state was lost before it could transfer its information."

The success of the device is due to a new circuit design that brings the wires closer to the qubit and reduces interference from other sources of electromagnetic radiation. To reduce this noise, the researchers put in filters that remove extraneous signals from the wires that lead to the device. The metal wires also shield the qubit. As a result, the qubits are 100 to 1000 times less noisy than the ones used in previous experiments.

Eventually the researchers plan to extend the device to work with an intrinsic property of the electron known as its spin. "In the long run we want systems where spin and charge are coupled together to make a spin qubit that can be electrically controlled," Petta said. "We've shown we can coherently couple an electron to light, and that is an important step toward coupling spin to light."

David DiVincenzo, a physicist at the Institute for Quantum Information in RWTH Aachen University in Germany, who was not involved in the research, is the author of an influential 1996 paper outlining five minimal requirements necessary for creating a quantum computer. Of the Princeton-HRL work, in which he was not involved, DiVincenzo said: "It has been a long struggle to find the right combination of conditions that would achieve the strong coupling condition for a single-electron qubit. I am happy to see that a region of parameter space has been found where the system can go for the first time into strong-coupling territory." [19]

Fast track control accelerates switching of quantum bits

From laptops to cellphones, today's technology advances through the ever-increasing speed at which electric charges are directed through circuits. Similarly, speeding up control over quantum states in atomic and nanoscale systems could lead to leaps for the emerging field of quantum technology.

An international collaboration between physicists at the University of Chicago, Argonne National Laboratory, McGill University, and the University of Konstanz recently demonstrated a new framework for faster control of a quantum bit. First published online Nov. 28, 2016, in Nature Physics, their experiments on a single electron in a diamond chip could create quantum devices that are less to prone to errors when operated at high speeds.

Accelerating quantum dynamics

To understand their experiment, one can look to the ultimate setting for speed in classical dynamics: the oval racetracks at the Indianapolis or Daytona 500. To enable the racecars to navigate the turns at awesome speeds, the racetrack's pavement is "banked" by up to 30 degrees. A student in Newtonian mechanics could explain that this inward slope of the pavement allows the normal force provided by the road to help cancel the car's centrifugal acceleration, or its tendency to slide outward from the turn. The greater the speed, the greater the bank angle that is required.

"The dynamics of quantum particles behave analogously," said Aashish Clerk, professor of theoretical physics at McGill University. "Although the equations of motion are different, to accurately change the state of a quantum particle at high speeds, you need to design the right track to impart the right forces."

Clerk, together with McGill postdoctoral fellows Alexandre Baksic and Hugo Ribeiro, formulated a new technique to enable faster quantum dynamics by deftly absorbing detrimental accelerations felt by the quantum particle. These accelerations, unless compensated, would divert the particle from its intended trajectory in the space of quantum states, similar to how the centrifugal acceleration deflects the racecar from its intended racing line on the track.

Through conversations with members of his own group and the Clerk group, David Awschalom, professor in spintronics and quantum information at the Institute for Molecular Engineering in the University of Chicago, realized that the new theory could be used to speed up the diamond-based quantum devices in his labs. However, just as constructing the banked speedways presented challenges in civil engineering, experimentally executing the control sequences envisioned by Clerk and co-workers presented ones in quantum engineering.

Building the quantum fast track required shining intricately-shaped, synchronized laser pulses on single electrons trapped at defects inside their diamond chips. This experimental feat was achieved by lead author Brian Zhou, working with Christopher Yale, F. Joseph Heremans, and Paul Jerger.

"We demonstrated that these new protocols could flip the state of a quantum bit, from 'off' to 'on,' 300% faster than conventional methods," said Awschalom, also a senior scientist at Argonne National Laboratory. "Shaving every nanosecond from the operation time is essential to reduce the impact of quantum decoherence," he explained, referring to the process by which quantum information is lost to the environment

Professor Guido Burkard and Adrian Auer from the University of Konstanz joined the Awschalom and Clerk groups to examine the data from the experiments. A leading expert in diamond-based quantum systems, Burkard remarked, "What is promising for translating these techniques beyond the laboratory is that they are effective even when the system is not perfectly isolated."

The researchers anticipate that their methods can be further applied for fast and accurate control over the physical motion of atoms or the transfer of quantum states between different systems, and convey benefits to quantum applications, such as secure communications and simulation of complex systems. [18]

Researchers improve qubit lifetime for quantum computers

An international team of scientists has succeeded in making further improvements to the lifetime of superconducting quantum circuits. An important prerequisite for the realization of high-performance quantum computers is that the stored data should remain intact for as long as possible. The researchers, including Jülich physicist Dr. Gianluigi Catelani, have developed and tested a technique that removes unpaired electrons from the circuits. These are known to shorten the qubit lifetime. The study is published online by the journal Science today.

Quantum computers could one day achieve significantly higher computing speeds than conventional digital computers in performing certain types of tasks. Superconducting circuits belong to the most promising candidates for implementing quantum bits, known as qubits, with which quantum computers can store and process information. The high error rates associated with previously available qubits have up to now limited the size and efficiency of quantum computers. Dr. Gianluigi Catelani of the Peter Grünberg Institute (PGI-2) in Jülich, together with his colleagues has now found a way to prolong the time in which the superconducting circuits are able to store a "0" or a "1" without errors. Beside Catelani, the team comprises researchers working in the USA (Massachusetts Institute of Technology, Lincoln Laboratory, and the University of California, Berkeley), Japan (RIKEN), and Sweden (Chalmers University of Technology).

When superconducting materials are cooled below a material-specific critical temperature, electrons come together to form pairs; then current can flow without resistance. However, so far it has not been possible to build superconducting circuits in which all electrons bundle together. Single electrons remain unpaired and are unable to flow without resistance. Due to these so-called quasiparticles, energy is lost and this limits the length of time that the circuits can store data.

Researchers have now developed and tested a technique that can temporarily remove unpaired electrons away from the circuit; with the help of microwave pulses, they are in effect "pumped out". This results in a three-fold improvement in the lifespan of the qubits.

"The technique can in principle be put to immediate use for all superconducting qubits", explained Catelani, who, as a theoretical physicist has contributed to the analysis and interpretation of the experimental data. However, he emphasised that the lifespan of qubits is only one of many hurdles in the development of complex quantum computers. Moreover, the new technique means that the quasiparticles are not permanently removed, but flow back again and again. The scientists have another solution ready to solve this problem: the pumping technique can be combined with another method that permanently traps the quasiparticles. Catelani, together with his colleagues from Jülich and Yale, has already analysed and tested such a quasiparticle "trap". Their results were published in September in the journal Physical Review B (DOI: 10.1103/PhysRevB.94.104516). [17]

Tracking the flow of quantum information

If objects in motion are like rainwater flowing through a gutter and landing in a puddle, then quantum objects in motion are like rainwater that might end up in a bunch of puddles, all at once. Figuring out where quantum objects actually go has frustrated scientists for years.

Now a Yale-led group of researchers has derived a formula for understanding where quantum objects land when they are transmitted. It's a development that offers insight for controlling open quantum systems in a variety of situations.

"The formula we derive turns out to be very useful in operating a quantum computer," said Victor Albert, first author of a study published in the journal Physical Review X. "Our result says that, in principle, we can engineer 'rain gutters' and 'gates' in a system to manipulate quantum objects, either after they land or during their actual flow."

In this case, the gutters and gates represent the idea of dissipation, a process that is usually destructive to fragile quantum properties, but that can sometimes be engineered to control and protect those properties.

The principal investigator of the research is Liang Jiang, assistant professor of applied physics and physics at Yale.

It is a fundamental principle of nature that objects will move until they reach a state of minimal energy, or grounding. But in quantum systems, there can be multiple groundings because quantum systems can exist in multiple states at the same time—what is known as superposition.

That's where the gutters and gates come in. Jiang, Albert, and their colleagues used these mechanisms to formulate the probability of quantum objects landing in one spot or the other. The formula also showed there was one situation in which superposition can never be sustained: when a quantum "droplet" in superposition has landed in one "puddle" already, but hasn't yet arrived at the other "puddle."

"In other words, such a superposition state always loses some of its quantum properties as the 'droplet' flows completely into both puddles," Albert said. "This is in some ways a negative result, but it is a bit surprising that it always holds."

Both aspects of the formula will be helpful in building quantum computers, Albert noted. As the research community continues to develop technological platforms capable of supporting such systems, Albert said, it will need to know "what is and isn't possible." [16]

An Archimedes' screw for groups of quantum particles

Anyone who has tried to lead a group of tourists through a busy city knows the problem. How do you keep the group together when they are constantly jostled, held up and distracted by the hubbub around them?

It's a problem the designers of quantum computers have to tackle. In some future quantum computers, information will be encoded in the delicate quantum states of groups of particles. These face jostling by noise and disorder within the materials of the processor. Now, an international team has proposed a scheme that could help protect groups of particles and enable them to move together without any getting lost or held up.

The proposal, published 17 November in Physical Review Letters, comes from researchers at the National University of Singapore (NUS), Technical University of Crete, University of Oxford and Google. Their paper puts forward a scheme that can reliably transport quantum states of a few photons along a line of miniature quantum circuits. Simulations show that it should efficiently move a three-photon state from one circuit site to the next over dozens of sites: the particles jump together throughout and finally appear at the other end undisturbed, with no spreading out.

The scheme is based on the ideas of physicist David J. Thouless, who won half the 2016 Nobel Prize in physics for his work on topological effects in materials. Topological effects are to do with geometry, and their use in quantum computing can help protect fragile quantum states during processing.

One of Thouless' major contributions was the invention of 'topological pumping'. This works something like Archimedes' screw pump for water. The Ancient Greek's screw spins around, but the water within it travels in a straight line up a hill. "Even though the motion of the machine is cyclical, the motion of the particles is not, they move in a line," explains Jirawat Tangpanitanon, first author on the paper and a PhD student in the group of Dimitris Angelakis at the Centre for Quantum Technologies (CQT) at NUS.

In the quantum scheme, the screw thread is not a physical structure but an oscillating external field imposed on the particles by electronic control over the device that contains them.

Angelakis started his group looking into topological pumping after others in 2015 demonstrated the effect for individual, non-interacting, particles. Angelakis, Tangpanitanon and Research Fellow Victor Bastidas wanted to find out if it would be possible to move groups of particles coherently too.

The answer is yes. What's more, unlike Archimedes' pump, which can only move water one way, the quantum particles can even be sent into reverse by changing the initial conditions. "It's like a moonwalk," jokes Tangpanitanon. It looks like everything should be moving forward, but instead the particles go backwards due to quantum effects.

Co-author Pedram Roushan - part of the Google group in Santa Barbara, California building superconducting circuits for quantum computing - and the team hopes to see the idea implemented in similar hardware. "This paper is almost a blueprint. We developed the proposal to match existing devices," says Angelakis, who is a Principal Investigator at CQT and a faculty member at the Technical University of Crete. [15]

Quantum dot LEDs that can produce entangled photons

Quantum computing is heralded as the next revolution in terms of global computing. Google, Intel and IBM are just some of the big names investing millions currently in the field of quantum computing which will enable faster, more efficient computing required to power the requirements of our future computing needs.

Now a researcher and his team at Tyndall National Institute in Cork have made a 'quantum leap' by developing a technical step that could enable the use of quantum computers sooner than expected.

Conventional digital computing uses 'on-off' switches, but quantum computing looks to harness quantum state of matters—such as entangled photons of light or multiple states of atoms—to encode information. In theory, this can lead to much faster and more powerful computer processing, but the technology to underpin quantum computing is currently difficult to develop at scale.

Researchers at Tyndall have taken a step forward by making quantum dot light-emitting diodes (LEDs) that can produce entangled photons (whose actions are linked), theoretically enabling their use to encode information in quantum computing.

This is not the first time that LEDs have been made that can produce entangled photons, but the methods and materials described in the new paper have important implications for the future of quantum technologies, explains researcher Dr Emanuele Pelucchi, Head of Epitaxy and Physics of Nanostructures and a member of the Science Foundation Ireland-funded Irish Photonic Integration Centre (IPIC) at Tyndall National Institute in Cork.

"The new development here is that we have engineered a scalable array of electrically driven quantum dots using easily-sourced materials and conventional semiconductor fabrication technologies, and our method allows you to direct the position of these sources of entangled photons," he says.

"Being able to control the positions of the quantum dots and to build them at scale are key factors to underpin more widespread use of quantum computing technologies as they develop."

The Tyndall technology uses nanotechnology to electrify arrays of the pyramid-shaped quantum dots so they produce entangled photons. "We exploit intrinsic nanoscale properties of the whole "pyramidal" structure, in particular, an engineered self-assembled vertical quantum wire, which selectively injects current into the vicinity of a quantum dot," explains Dr Pelucchi.

"The reported results are an important step towards the realisation of integrated quantum photonic circuits designed for quantum information processing tasks, where thousands or more sources would function in unison."

"It is exciting to see how research at Tyndall continues to break new ground, particularly in relation to this development in quantum computing. The significant breakthrough by Dr Pelucchi advances our understanding of how to harness the opportunity and power of quantum computing and undoubtedly accelerates progress in this field internationally. Photonics innovations by the IPIC team at Tyndall are being commercialised across a number sectors and as a result, we are directly driving global innovation through our investment, talent and research in this area," said Dr Kieran Drain, CEO at Tyndall National Institute. [14]

Team demonstrates large-scale technique to produce quantum dots

A method to produce significant amounts of semiconducting nanoparticles for light-emitting displays, sensors, solar panels and biomedical applications has gained momentum with a demonstration by researchers at the Department of Energy's Oak Ridge National Laboratory.

While zinc sulfide nanoparticles - a type of quantum dot that is a semiconductor - have many potential applications, high cost and limited availability have been obstacles to their widespread use. That could change, however, because of a scalable ORNL technique outlined in a paper published in Applied Microbiology and Biotechnology.

Unlike conventional inorganic approaches that use expensive precursors, toxic chemicals, high temperatures and high pressures, a team led by ORNL's Ji-Won Moon used bacteria fed by inexpensive sugar at a temperature of 150 degrees Fahrenheit in 25- and 250-gallon reactors. Ultimately, the team produced about three-fourths of a pound of zinc sulfide nanoparticles - without process optimization, leaving room for even higher yields.

The ORNL biomanufacturing technique is based on a platform technology that can also produce nanometer-size semiconducting materials as well as magnetic, photovoltaic, catalytic and phosphor materials. Unlike most biological synthesis technologies that occur inside the cell, ORNL's biomanufactured quantum dot synthesis occurs outside of the cells. As a result, the nanomaterials are produced as loose particles that are easy to separate through simple washing and centrifuging.

The results are encouraging, according to Moon, who also noted that the ORNL approach reduces production costs by approximately 90 percent compared to other methods.

"Since biomanufacturing can control the quantum dot diameter, it is possible to produce a wide range of specifically tuned semiconducting nanomaterials, making them attractive for a variety of applications that include electronics, displays, solar cells, computer memory, energy storage, printed electronics and bio-imaging," Moon said.

Successful biomanufacturing of light-emitting or semiconducting nanoparticles requires the ability to control material synthesis at the nanometer scale with sufficiently high reliability, reproducibility and yield to be cost effective. With the ORNL approach, Moon said that goal has been achieved.

Researchers envision their quantum dots being used initially in buffer layers of photovoltaic cells and other thin film-based devices that can benefit from their electro-optical properties as light-emitting materials. [13]

Superfast light source made from artificial atom

All light sources work by absorbing energy – for example, from an electric current – and emit energy as light. But the energy can also be lost as heat and it is therefore important that the light sources emit the light as quickly as possible, before the energy is lost as heat. Superfast light sources can be used, for example, in laser lights, LED lights and in single-photon light sources for quantum technology. New research results from the Niels Bohr Institute show that light sources can be made much faster by using a principle that was predicted theoretically in 1954. The results are published in the scientific journal, Physical Review Letters.

Researchers at the Niels Bohr Institute are working with quantum dots, which are a kind of artificial atom that can be incorporated into optical chips. In a quantum dot, an electron can be excited (i.e. jump up), for example, by shining a light on it with a laser and the electron leaves a 'hole'. The stronger the interaction between light and matter, the faster the electron decays back into the hole and the faster the light is emitted.

But the interaction between light and matter is naturally very weak and it makes the light sources very slow to emit light and this can reduce energy efficiency.

Already in 1954, the physicist Robert Dicke predicted that the interaction between light and matter could be increased by having a number of atoms that 'share' the excited state in a quantum superposition.

Quantum speed up

Demonstrating this effect has been challinging so far because the atoms either come so close together that they bump into each other or they are so far apart that the quantum speed up does not work. Researchers at the Niels Bohr Institute have now finally demonstrated the effect experimentally, but in an entirely different physical system than Dicke had in mind. They have shown this so-called superradiance for photons emitted from a single quantum dot.

"We have developed a quantum dot so that it behaves as if it was comprised of five quantum dots, which means that the light is five times stronger. This is due to the attraction between the electron and the hole. But what is special is that the quantum dot still only emits a single photon at a time. It is an outstanding single-photon source," says Søren Stobbe, who is an associate professor in the Quantum Photonic research group at the Niels Bohr Institute at the University of Copenhagen and led the project. The experiment was carried out in collaboration with Professor David Ritchie's research group at the University of Cambridge, who have made the quantum dots.

Petru Tighineanu, a postdoc in the Quantum Photonics research group at the Niels Bohr Institute, has carried out the experiments and he explains the effect as such, that the atoms are very small and light is very 'big' because of its long wavelength, so the light almost cannot 'see' the atoms – like a lorry that is driving on a road and does not notice a small pebble. But if many pebbles become a larger stone, the lorry will be able to register it and then the interaction becomes much more dramatic. In the same way, light interacts much more strongly with the quantum dot if the quantum dot contains the special superradiant quantum state, which makes it look much bigger.

Increasing the light-matter interaction

"The increased light-matter interaction makes the quantum dots more robust in regards to the disturbances that are found in all materials, for example, acoustic oscillations. It helps to make the photons more uniform and is important for how large you can build future quantum computers," says Søren Stobbe.

He adds that it is actually the temperature, which is only a few degrees above absolute zero, that limits how fast the light emissions can remain in their current experiments. In the long term, they will study the quantum dots at even lower temperatures, where the effects could be very dramatic. [12]

Single-photon source is efficient and indistinguishable

Devices that emit one – and only one – photon on demand play a central role in light-based quantum-information systems. Each photon must also be emitted in the same quantum state, which makes each photon indistinguishable from all the others. This is important because the quantum state of the photon is used to carry a quantum bit (qubit) of information.

Quantum dots are tiny pieces of semiconductor that show great promise as single-photon sources. When a laser pulse is fired at a quantum dot, an electron is excited between two distinct energy levels. The excited state then decays to create a single photon with a very specific energy. However, this process can involve other electron excitations that result in the emission of photons with a wide range of energies – photons that are therefore not indistinguishable.

Exciting dots

This problem can be solved by exciting the quantum dot with a pulse of light at the same energy as the emitted photon. This is called resonance fluorescence, and has been used to create devices that are very good at producing indistinguishable single photons. However, this process is inefficient, and only produces a photon about 6% of the time.

Now, Chaoyang Lu, Jian-Wei Pan and colleagues at the University of Science and Technology of China have joined forces with researchers in Denmark, Germany and the UK to create a resonance-fluorescence-based source that emits a photon 66% of the time when it is prompted by a laser pulse.

Of these photons, 99.1% are solo and 98.5% are in indistinguishable quantum states – with both figures of merit being suitable for applications in quantum-information systems.

Lu told physicsworld.com that nearly all of the laser pulses that strike the source produce a photon, but about 34% of these photons are unable to escape the device. The device was operated at a laser-pulse frequency of 81 MHz and a pulse power of 24 nW, which is a much lower power requirement than other quantum-dot-based sources.

Quantum sandwich

The factor-of-ten improvement in efficiency was achieved by sandwiching a quantum dot in the centre of a "micropillar" created by stacking 40 disc-like layers (see figure). Each layer is a "distributed Bragg reflector", which is a pair of mirrors that together have a thickness of one quarter the wavelength of the emitted photons.

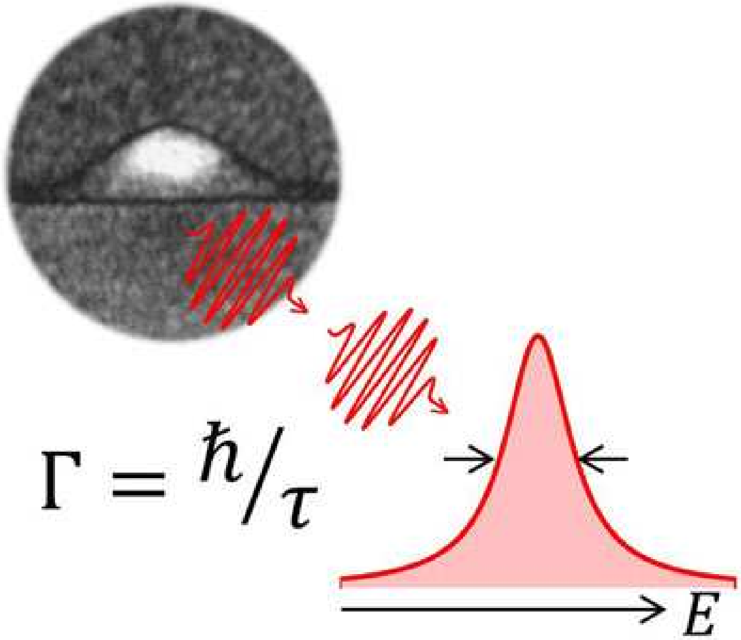
The micropillar is about 2.5 µm in diameter and about 10 µm tall, and it allowed the team to harness the "Purcell effect", whereby the rate of fluorescence is increased significantly when the emitter is placed in a resonant cavity.

Lu says that the team is already thinking about how the photon sources could be used to perform boson sampling (see "'Boson sampling' offers shortcut to quantum computing"). This involves a network of beam splitters that converts one set of photons arriving at a number of parallel input ports into a second set leaving via a number of parallel outputs. The "result" of the computation is the probability that a certain input configuration will lead to a certain output. This result cannot be easily calculated using a conventional computer, and this has led some physicists to suggest that boson sampling could be used to solve practical problems that would take classical computers vast amounts of time to solve.

Other possible applications for the source are the quantum teleportation of three properties of a quantum system – the current record is two properties and is held by Lu and Pan – or quantum cryptography.

The research is described in Physical Review Letters. [11]

Semiconductor quantum dots as ideal single-photon source



A single-photon source never emits two or more photons at the same time. Single photons are important in the field of quantum information technology where, for example, they are used in quantum computers. Alongside the brightness and robustness of the light source, the indistinguishability of the photons is especially crucial. In particular, this means that all photons must be the same color. Creating such a source of identical single photons has proven very difficult in the past.

However, quantum dots made of semiconductor materials are offering new hope. A quantum dot is a collection of a few hundred thousand atoms that can form itself into a semiconductor under certain conditions. Single electrons can be captured in these quantum dots and locked into a very small area. An individual photon is emitted when an engineered quantum state collapses.

Noise in the semiconductor

A team of scientists led by Dr. Andreas Kuhlmann and Prof. Richard J. Warburton from the University of Basel have already shown in past publications that the indistinguishability of the photons is reduced by the fluctuating nuclear spin of the quantum dot atoms. For the first time ever, the scientists have managed to control the nuclear spin to such an extent that even photons sent out at very large intervals are the same color.

Quantum cryptography and quantum communication are two potential areas of application for single-photon sources. These technologies could make it possible to perform calculations that are far beyond the capabilities of today's computers. [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.
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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 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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