Single-Atom Magnet Data Storage

EPFL scientists have built a single-atom magnet that is the most stable to-date. The breakthrough paves the way for the scalable production of miniature magnetic storage devices. [11]

Researchers at the Okinawa Institute of Science and Technology Graduate University (OIST) have identified a system that could store quantum information for longer times, which is critical for the future of quantum computing. [10]

Around the world, small bands of such engineers have been working on this approach for decades. Using two particular quantum phenomena, called superposition and entanglement, they have created qubits and linked them together to make prototype machines that exist in many states simultaneously. Such quantum computers do not require an increase in speed for their power to increase. In principle, this could allow them to become far more powerful than any classical machine—and it now looks as if principle will soon be turned into practice. Big firms, such as Google, Hewlett-Packard, IBM and Microsoft, are looking at how quantum computers might be commercialized. The world of quantum computation is almost here. [9]

IBM scientists today unveiled two critical advances towards the realization of a practical quantum computer. For the first time, they showed the ability to detect and measure both kinds of quantum errors simultaneously, as well as demonstrated a new, square quantum bit circuit design that is the only physical architecture that could successfully scale to larger dimensions. [8]

Physicists at the Universities of Bonn and Cambridge have succeeded in linking two completely different quantum systems to one another. In doing so, they have taken an important step forward on the way to a quantum computer. To accomplish their feat the researchers used a method that seems to function as well in the quantum world as it does for us people: teamwork. The results have now been published in the "Physical Review Letters". [7]

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

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.

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

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

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Preface

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

Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems. [8]

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.

Single-atom magnet breaks new ground for future data storage

Magnetic storage devices such as computer hard drives or memory cards are widespread today. But as computer technology grows smaller, there is a need to also miniaturize data storage. This is epitomized by an effort to build magnets the size of a single atom. However, a magnet that small is very hard to keep "magnetized", which means that it would be unable to retain information for a meaningful amount time. In a breakthrough study published in Science, researchers led by EPFL have now built a single-atom magnet that, although working at around 40 Kelvin (-233.15 C), is the smallest and most stable to date.

Magnets work because of electron spin, which is a complicated motion best imagined as a spinning top. Electrons can spin up or down (something like clockwise or anti-clockwise), which creates a tiny magnetic field. In an atom, electrons usually come in pairs with opposite spins, thus cancelling out each other's magnetic field. But in a magnet, atoms have unpaired electrons, and their spins create an overall magnetic field.

A challenge today is to build smaller and smaller magnets that can be implemented in data storage devices. The problem is something called "magnetic remanence", which describes the ability of a magnet to remain magnetized. Remanence is very difficult to observe from a single atom, because environmental fluctuations can flip its magnetic fields. In terms of technology, a limited remanence would mean limited information storage for atom-sized magnets.

A team of scientists led by Harald Brune at EPFL and his colleagues at ETH Zurich, have built a prototypical single-atom magnet based on atoms of the rare-earth element holmium. The researchers, placed single holmium atoms on ultrathin films of magnesium oxide, which were previously grown on a surface of silver. This method allows the formation of single-atom magnets with robust remanence. The reason is that the electron structure of holmium atoms protects the magnetic field from being flipped.

The magnetic remanence of the holmium atoms is stable at temperatures around 40 Kelvin (-233.15 oC), which, though far from room temperature, are the highest achieved ever. The scientists' calculations demonstrate that the remanence of single holmium atoms at these temperatures is much higher than the remanence seen in previous magnets, which were also made up of 3-12 atoms. This makes the new single-atom magnet a worldwide record in terms of both size and stability. [11]

Quantum computer storage may require the help of an intermediary to transmit information

Quantum computing—which aims to use particles on the atomic scale to make calculations and store the results—has the potential to solve some key problems much faster than current computers.

To make quantum computing a reality, scientists must find a system that remains stable long enough to make the calculations. While this is an extremely short time frame, only thousandths of a second, the particles involved are so small that they are easily influenced by their surroundings. If the motion of the particles is disturbed, even a little, it throws off the whole calculation.

Nuclei are promising contenders for quantum memory because they are not easily influenced by their surroundings. However, that also makes them extremely difficult to manipulate. Many quantum physicists have tried with little success.

"In usual materials it is very difficult to control nuclei directly," said Prof. Denis Konstantinov, who runs the Quantum Dynamics Unit at OIST.

Instead of trying control the nucleus directly, the researchers focused on a "middle man" of sorts – the electrons orbiting the nucleus.

The nucleus has a tiny internal magnet, called a "magnetic moment," and the electrons orbiting around it also have magnetic moments that are about 1,000 times larger. Those magnets interact with each other, which is called the "hyperfine interaction."

Quantum computer storage may require the help of an intermediary to transmit information

Superconducting magnet for quantum experiment

The hyperfine interaction is stronger in some materials than others. The researchers found that a crystal made of manganese and some other elements has a strong hyperfine interaction. This enabled them to manipulate the nuclei by first targeting the electrons.

Information in quantum computing is conveyed by photons, which are individual particles of light, which also make up other nonvisible electromagnetic waves, such as ultraviolet and microwaves. The information transmitted is actually the quantum state of the photon. The quantum state of the photon needs to be transferred to another particle so it will last long enough for the computation to take place.

In this experiment, the researchers beamed microwaves through a manganese carbonate crystal. The magnetic field of the microwaves interacted with the magnetic moments of the electrons that are orbiting around the nuclei of the manganese atoms. The electrons' movements started to change, which in turn altered the movement of the nuclei because they are connected by the hyperfine interaction. The quantum state of the microwave photon was transferred to the nuclei when the nuclei's internal magnets flipped to point in the opposite direction.

This all has to happen very quickly before the quantum state of the photon changes. To transmit the information and flip the nuclei fast enough, there has to be a strong connection between the microwaves and nuclei via the electrons.

"To our knowledge, our experiment is the first demonstration of the strong coupling between microwave photons and nuclear spins," said Leonid Abdurakhimov, a post-doctoral scholar at OIST and first author of the paper.

Next, the team plans to cool down the system to nearly -273 C, or -500 F, to see if they can strengthen the connection and extend the time information can be stored by minimizing temperature fluctuations.

"We are making the first and important steps towards using an ensemble of nuclear spins for quantum memory," Konstantinov said. "We now have a whole class of materials that can be used for this purpose. Future experiments promise to be quite exciting." [10]

After decades languishing in the laboratory, quantum computers are attracting commercial interest

Around the world, small bands of such engineers have been working on this approach for decades. Using two particular quantum phenomena, called superposition and entanglement, they have created qubits and linked them together to make prototype machines that exist in many states simultaneously. Such quantum computers do not require an increase in speed for their power to increase. In principle, this could allow them to become far more powerful than any classical machine—and it now looks as if principle will soon be turned into practice. Big firms, such as Google, Hewlett-Packard, IBM and Microsoft, are looking at how quantum computers might be commercialised. The world of quantum computation is almost here.

A Shor thing

As with a classical bit, the term qubit is used, slightly confusingly, to refer both to the mathematical value recorded and the element of the computer doing the recording. Quantum uncertainty means that, until it is examined, the value of a qubit can be described only in terms of probability. Its possible states, zero and one, are, in the jargon, superposed—meaning that to some degree the qubit is in one of these states, and to some degree it is in the other. Those superposed probabilities can, moreover, rise and fall with time.

The other pertinent phenomenon, entanglement, is caused because qubits can, if set up carefully so that energy flows between them unimpeded, mix their probabilities with one another. Achieving this is tricky. The process of entanglement is easily disrupted by such things as heat-induced vibration. As a result, some quantum computers have to work at temperatures close to absolute zero. If entanglement can be achieved, though, the result is a device that, at a given instant, is in all of the possible states permitted by its qubits' probability mixtures. Entanglement also means that to operate on any one of the entangled qubits is to operate on all of them. It is these two things which give quantum computers their power.

Harnessing that power is, nevertheless, hard. Quantum computers require special algorithms to exploit their special characteristics. Such algorithms break problems into parts that, as they are run through the ensemble of qubits, sum up the various probabilities of each qubit's value to arrive at the most likely answer.

One example—Shor's algorithm, invented by Peter Shor of the Massachusetts Institute of Technology—can factorize any non-prime number. Factorizing large numbers stumps classical computers and, since most modern cryptography relies on such factorizations being difficult, there are a lot of worried security experts out there. Cryptography, however, is only the beginning. Each of the firms looking at quantum computers has teams of mathematicians searching for other things that lend themselves to quantum analysis, and crafting algorithms to carry them out.

Top of the list is simulating physics accurately at the atomic level. Such simulation could speed up the development of drugs, and also improve important bits of industrial chemistry, such as the energy-greedy Haber process by which ammonia is synthesized for use in much of the world's fertilizer. Better understanding of atoms might lead, too, to better ways of desalinating seawater or sucking carbon dioxide from the atmosphere in order to curb climate change. It may even result in a better understanding of superconductivity, permitting the invention of a superconductor that works at room temperature. That would allow electricity to be transported without losses.

Quantum computers are not better than classical ones at everything. They will not, for example, download web pages any faster or improve the graphics of computer games. But they would be able to handle problems of image and speech recognition, and real-time language translation. They should also be well suited to the challenges of the big-data era, neatly extracting wisdom from the screeds of messy information generated by sensors, medical records and stock markets. For the firm that makes one, riches await.

Cue bits

How best to do so is a matter of intense debate. The biggest question is what the qubits themselves should be made from.

A qubit needs a physical system with two opposite quantum states, such as the direction of spin of an electron orbiting an atomic nucleus. Several things which can do the job exist, and each has its fans. Some suggest nitrogen atoms trapped in the crystal lattices of diamonds. Calcium ions held in the grip of magnetic fields are another favorite. So are the photons of which light is composed (in this case the qubit would be stored in the plane of polarization). And quasiparticles, which are vibrations in matter that behave like real subatomic particles, also have a following.

The leading candidate at the moment, though, is to use a superconductor in which the qubit is either the direction of a circulating current, or the presence or absence of an electric charge. Both Google and IBM are banking on this approach. It has the advantage that superconducting qubits can be arranged on semiconductor chips of the sort used in existing computers. That, the two firms think, should make them easier to commercialize.

Those who back photon qubits argue that their runner will be easy to commercialize, too. As one of their number, Jeremy O'Brien of Bristol University, in England, observes, the computer industry is making more and more use of photons rather than electrons in its conventional products. Quantum computing can take advantage of that—a fact that has not escaped Hewlett-Packard, which is already expert in shuttling data encoded in light between data centers. The firm once had a research program looking into qubits of the nitrogen-in-diamond variety, but its researchers found bringing the technology to commercial scale tricky. Now Ray Beausoleil, one of HP's fellows, is working closely with Dr O'Brien and others to see if photonics is the way forward.

For its part, Microsoft is backing a more speculative approach. This is spearheaded by Michael Freedman, a famed mathematician (he is a recipient of the Fields medal, which is regarded by mathematicians with the same awe that a Nobel Prize evokes among scientists). Dr Freedman aims to use ideas from topology—a description of how the world is folded up in space and time—to crack the problem. Quasiparticles called anyons, which move in only two dimensions, would act as his qubits. His difficulty is that no usable anyon has yet been confirmed to exist. But laboratory results suggesting one has been spotted have given him hope. And Dr Freedman believes the superconducting approach may be hamstrung by the need to correct errors—errors a topological quantum computer would be inherently immune to, because its qubits are shielded from jostling by the way space is folded up around them.

For non-anyonic approaches, correcting errors is indeed a serious problem. Tapping into a qubit prematurely, to check that all is in order, will destroy the superposition on which the whole system relies. There are, however, ways around this.

In March John Martinis, a renowned quantum physicist whom Google headhunted last year, reported a device of nine qubits that contained four which can be interrogated without disrupting the other five. That is enough to reveal what is going on. The prototype successfully detected bit-flip errors, one of the two kinds of snafu that can scupper a calculation. And in April, a team at IBM reported a four-qubit version that can catch both those and the other sort, phase-flip errors.

Google is also collaborating with D-Wave of Vancouver, Canada, which sells what it calls quantum annealers. The field's practitioners took much convincing that these devices really do exploit the quantum advantage, and in any case they are limited to a narrower set of problems—such as searching for images similar to a reference image. But such searches are just the type of application of interest to Google. In 2013, in collaboration with NASA and USRA, a research consortium, the firm bought a D-Wave machine in order to put it through its paces. Hartmut Neven, director of engineering at Google Research, is guarded about what his team has found, but he believes D-Wave's approach is best suited to calculations involving fewer qubits, while Dr Martinis and his colleagues build devices with more.

Which technology will win the race is anybody's guess. But preparations are already being made for its arrival—particularly in the light of Shor's algorithm.

Spooky action

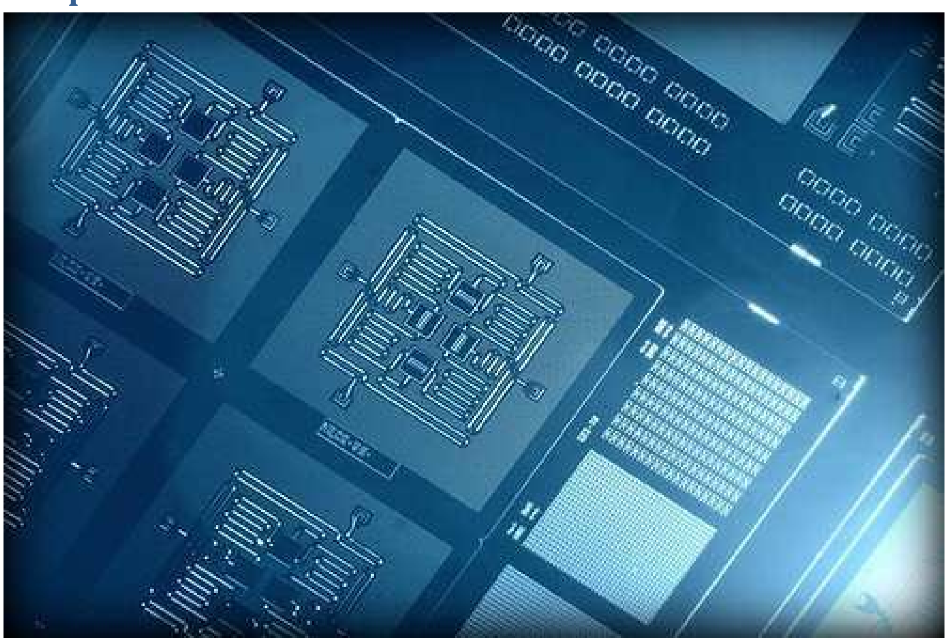
Documents released by Edward Snowden, a whistleblower, revealed that the Penetrating Hard Targets program of America's National Security Agency was actively researching "if, and how, a cryptologically useful quantum computer can be built". In May IARPA, the American government's intelligence-research arm, issued a call for partners in its Logical Qubits program, to make robust, error-free qubits. In April, meanwhile, Tanja Lange and Daniel Bernstein of Eindhoven

University of Technology, in the Netherlands, announced PQCRYPTO, a programme to advance and standardize “post-quantum cryptography”. They are concerned that encrypted communications captured now could be subjected to quantum cracking in the future. That means strong pre-emptive encryption is needed immediately.

Quantum-proof cryptomaths does already exist. But it is clunky and so eats up computing power. PQCRYPTO’s objective is to invent forms of encryption that sidestep the maths at which quantum computers excel while retaining that mathematics’ slimmed-down computational elegance.

Ready or not, then, quantum computing is coming. It will start, as classical computing did, with clunky machines run in specialist facilities by teams of trained technicians. Ingenuity being what it is, though, it will surely spread beyond such experts’ grip. Quantum desktops, let alone tablets, are, no doubt, a long way away.
But, in a neat circle of cause and effect, if quantum computing really can help create a room-temperature superconductor, such machines may yet come into existence. [9]

Scientists achieve critical steps to building first practical quantum computer



Layout of IBM's four superconducting quantum bit device. Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems.

With Moore's Law expected to run out of steam, quantum computing will be among the inventions that could usher in a new era of innovation across industries.
Quantum computers promise to open up new capabilities in the fields of optimization and simulation simply not possible using today's computers. If a quantum computer could be built with

just 50 quantum bits (qubits), no combination of today's TOP500 supercomputers could successfully outperform it.

The IBM breakthroughs, described in the April 29 issue of the journal Nature Communications, show for the first time the ability to detect and measure the two types of quantum errors (bit-flip and phase-flip) that will occur in any real quantum computer. Until now, it was only possible to address one type of quantum error or the other, but never both at the same time. This is a necessary step toward quantum error correction, which is a critical requirement for building a practical and reliable large-scale quantum computer.

IBM's novel and complex quantum bit circuit, based on a square lattice of four superconducting qubits on a chip roughly one-quarter-inch square, enables both types of quantum errors to be detected at the same time. By opting for a square-shaped design versus a linear array – which prevents the detection of both kinds of quantum errors simultaneously – IBM's design shows the best potential to scale by adding more qubits to arrive at a working quantum system.

"Quantum computing could be potentially transformative, enabling us to solve problems that are impossible or impractical to solve today," said Arvind Krishna, senior vice president and director of IBM Research. "While quantum computers have traditionally been explored for cryptography, one area we find very compelling is the potential for practical quantum systems to solve problems in physics and quantum chemistry that are unsolvable today. This could have enormous potential in materials or drug design, opening up a new realm of applications."

For instance, in physics and chemistry, quantum computing could allow scientists to design new materials and drug compounds without expensive trial and error experiments in the lab, potentially speeding up the rate and pace of innovation across many industries.

For a world consumed by Big Data, quantum computers could quickly sort and curate ever larger databases as well as massive stores of diverse, unstructured data. This could transform how people make decisions and how researchers across industries make critical discoveries.

One of the great challenges for scientists seeking to harness the power of quantum computing is controlling or removing quantum decoherence – the creation of errors in calculations caused by interference from factors such as heat, electromagnetic radiation, and material defects. The errors are especially acute in quantum machines, since quantum information is so fragile.

"Up until now, researchers have been able to detect bit-flip or phase-flip quantum errors, but never the two together. Previous work in this area, using linear arrangements, only looked at bit-flip errors offering incomplete information on the quantum state of a system and making them inadequate for a quantum computer," said Jay Gambetta, a manager in the IBM Quantum Computing Group. "Our four qubit results take us past this hurdle by detecting both types of quantum errors and can be scalable to larger systems, as the qubits are arranged in a square lattice as opposed to a linear array."

The work at IBM was funded in part by the IARPA (Intelligence Advanced Research Projects Activity) multi-qubit-coherent-operations program.

Detecting quantum errors

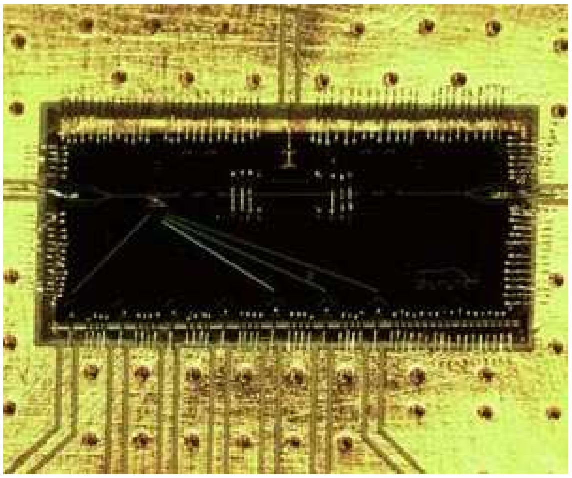
The most basic piece of information that a typical computer understands is a bit. Much like a beam of light that can be switched on or off, a bit can have only one of two values: "1" or "0". However, a quantum bit (qubit) can hold a value of 1 or 0 as well as both values at the same time, described as superposition and simply denoted as "0+1". The sign of this superposition is important because both states 0 and 1 have a phase relationship to each other. This superposition property is what allows quantum computers to choose the correct solution amongst millions of possibilities in a time much faster than a conventional computer.

Two types of errors can occur on such a superposition state. One is called a bit-flip error, which simply flips a 0 to a 1 and vice versa. This is similar to classical bit-flip errors and previous work has showed how to detect these errors on qubits. However, this is not sufficient for quantum error correction because phase-flip errors can also be present, which flip the sign of the phase relationship between 0 and 1 in a superposition state. Both types of errors must be detected in order for quantum error correction to function properly.

Quantum information is very fragile because all existing qubit technologies lose their information when interacting with matter and electromagnetic radiation.
Theorists have found ways to preserve the information much longer by spreading information across many physical qubits. "Surface code" is the technical name for a specific error correction scheme which spreads quantum information across many qubits. It allows for only nearest neighbor interactions to encode one logical qubit, making it sufficiently stable to perform error-free operations.

The IBM Research team used a variety of techniques to measure the states of two independent syndrome (measurement) qubits. Each reveals one aspect of the quantum information stored on two other qubits (called code, or data qubits). Specifically, one syndrome qubit revealed whether a bit-flip error occurred to either of the code qubits, while the other syndrome qubit revealed whether a phase-flip error occurred. Determining the joint quantum information in the code qubits is an essential step for quantum error correction because directly measuring the code qubits destroys the information contained within them. [8]

Next important step toward quantum computer



When facing big challenges, it is best to work together. In a team, the individual members can contribute their individual strengths - to the benefit of all those involved. One may be an absent-minded scientist who has brilliant ideas, but quickly forgets them. He needs the help of his conscientious colleague, who writes everything down, in order to remind the scatterbrain about it later. It's very similar in the world of quanta.

There the so-called quantum dots (abbreviated: qDots) play the role of the forgetful genius. Quantum dots are unbeatably fast, when it comes to disseminating quantum information. Unfortunately, they forget the result of the calculation just as quickly - too quickly to be of any real use in a quantum computer.

In contrast, charged atoms, called ions, have an excellent memory: They can store quantum information for many minutes. In the quantum world, that is an eternity.

They are less well suited for fast calculations, however, because the internal processes are comparatively slow.

The physicists from Bonn and Cambridge have therefore obliged both of these components, qDots and ions, to work together as a team. Experts speak of a hybrid system, because it combines two completely different quantum systems with one another.

Absent-minded qDots

qDots are considered the great hopes in the development of quantum computers. In principle, they are extremely miniaturized electron storage units. qDots can be produced using the same techniques as normal computer chips. To do so, it is only necessary to miniaturize the structures on the chips until they hold just one single electron (in a conventional PC it is 10 to 100 electrons).

The electron stored in a qDot can take on states that are predicted by quantum theory. However, they are very short-lived: They decay within a few picoseconds (for illustration: in one picosecond, light travels a distance of just 0.3 millimeters).

This decay produces a small flash of light: a photon. Photons are wave packets that vibrate in a specific plane - the direction of polarization. The state of the qDots determines the direction of polarization of the photon. "We used the photon to excite an ion", explains Prof. Dr. Michael Kohl from the Institute of Physics at the University of Bonn. "Then we stored the direction of polarization of the photon".

Conscientious ions

To do so, the researchers connected a thin glass fiber to the qDot. They transported the photon via the fiber to the ion many meters away. The fiberoptic networks used in telecommunications operate very similarly. To make the transfer of information as efficient as possible, they had trapped the ion between two mirrors. The mirrors bounced the photon back and forth like a ping pong ball, until it was absorbed by the ion.

"By shooting it with a laser beam, we were able to read out the ion that was excited in this way", explains Prof. Kohl. "In the process, we were able to measure the direction of polarization of the previously absorbed photon". In a sense then, the state of the qDot can be preserved in the ion - theoretically this can be done for many minutes. [7]

Quantum Computing

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

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

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

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

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

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

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

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

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

Quantum Entanglement

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

The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.
The same thing happens on the atomic scale giving a 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 $\boldsymbol{E = h\nu}$ and $\boldsymbol{E = mc^2}$, $\boldsymbol{m = h\nu / c^2}$ that is the $\boldsymbol{m}$ depends only on the $\boldsymbol{\nu}$ frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the $\boldsymbol{m_o}$ inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [2]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

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

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

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

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

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

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The Higgs boson

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

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

Higgs mechanism and Quantum Gravity

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

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

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

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

What is the Spin?

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

The Graviton

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

Conclusions

Ready or not, then, quantum computing is coming. It will start, as classical computing did, with clunky machines run in specialist facilities by teams of trained technicians. Ingenuity being what it is, though, it will surely spread beyond such experts' grip. Quantum desktops, let alone tablets, are, no doubt, a long way away. But, in a neat circle of cause and effect, if quantum computing really can help create a room-temperature superconductor, such machines may yet come into existence. [9]
Because these qubits can be designed and manufactured using standard silicon fabrication techniques, IBM anticipates that once a handful of superconducting qubits can be manufactured reliably and repeatedly, and controlled with low error rates, there will be no fundamental obstacle to demonstrating error correction in larger lattices of qubits. [8]
This success is an important step on the still long and rocky road to a quantum computer. In the long term, researchers around the world are hoping for true marvels from this new type of computer:

Certain tasks, such as the factoring of large numbers, should be child's play for such a computer. In contrast, conventional computers find this a really tough nut to crack. However, a quantum computer displays its talents only for such special tasks: For normal types of basic computations, it is pitifully slow. [7]
One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible 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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