Muon Spin Tales

Scientists at U.S. Department of Energy (DOE) national laboratories are collaborating to test a magnetic property of the muon. Their experiment could point to the existence of physics beyond our current understanding, including undiscovered particles. [14]

Muons are mysterious, and scientists are diving deep into the particle to get a handle on a property that might render it—and the universe—a little less mysterious. [13]

For elementary particles, such as muons or neutrinos, the magnetic force applied to such charges is unique and immutable. However, unlike the electric charge, the magnetic force strength is not quantised. [12]

Particle physics and decorative glassware are two disciplines that don't often meet. But given the striking results of a recent artist-scientist collaboration, perhaps that could change. [11]

Physicists at Chalmers University of Technology and Free University of Brussels have now found a method to significantly enhance optical force. [10]

Nature Communications today published research by a team comprising Scottish and South African researchers, demonstrating entanglement swapping and teleportation of orbital angular momentum 'patterns' of light. [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.

Muons spin tales of undiscovered particles

Scientists at U.S. Department of Energy (DOE) national laboratories are collaborating to test a magnetic property of the muon. Their experiment could point to the existence of physics beyond our current understanding, including undiscovered particles.

The experiment follows one that began in 1999 at the DOE's Brookhaven National Laboratory in which scientists measured the spin precession of the muon—i.e., the speed at which its spin changes direction—to be different from the theoretical predictions. Scientists from Argonne National Laboratory and Fermi National Accelerator Laboratory, along with collaborators from more than 25 other institutions, are recreating the experiment with much higher precision to confirm or disprove the former earlier results.

The muon is like the (very) big brother of the electron; they have the same charge, but the muon is over 200 times more massive. The two also share the same spin, a quantum mechanical property that determines a particle's behavior in the presence of a magnetic field.

Particles with spin act like tiny magnets, and when placed in a magnetic field, their spins change direction in a circular motion, much like a spinning gyroscope. The speed of a particle's spin precession is determined by a quantity known as its g-factor, which depends on the particle's spin and the strength of the magnetic field in which it moves.

In modern quantum mechanical theories, the vacuum is not empty. It is full of bubbles of so-called virtual particles, appearing and disappearing very quickly. Interactions between these virtual particles and a real particle, like the muon, can change how the real particle interacts with the magnetic field, affecting its g-factor. Theoretical physicists have calculated, based on our current understanding of the fundamental structure of nature, all the ways that each known particle affects the muon's g-factor, but the measurements that Brookhaven scientists took differed from what they expected by a few parts per million. This difference, if it persists in the new experiment, would point to completely new physics—an exciting discovery for particle physicists.

"If there is actually a discrepancy between the predicted and measured values, it is further proof that the Standard Model, our current understanding of the contents of the universe, is incomplete," said Argonne physicist Peter Winter. "The unexpected effect could be due to an undiscovered particle."

In the new experiment, sited at Fermilab, a beam will travel in a circle through a large, hollow ring due to the presence of a strong magnetic field. The same magnetic field will also lead to the precession of the muon spins while they circle around the ring. The scientists can calculate the g-factor by detecting the spin precession of the muons and knowing the magnetic field strength in the ring.

To achieve the desired precision, both the spin precession frequency and the strength of the magnetic field have to be measured with uncertainties below 70 parts per billion. The research group at Argonne has taken responsibility for measuring the magnetic field to such high precision. "The game of our experiment is to control any systematic uncertainty that could distort our precise measurements," said Winter.

This level of precision requires very sensitive probing devices that the scientists calibrated using highly stable and isolated fields produced by recycled magnetic resonance imaging machines at Argonne.

Once they calibrated the probes, the scientists placed 17 of them on a circular trolley that moves about the ring at Fermilab. The trolley measures the field at around 10,000 points, creating a map of the field strength everywhere in the ring. The trolley rests on two rails running along the sides of the tube, and the scientists move the trolley around the ring using two cables attached to motorized spools.

"This trolley has to move in a vacuum," said Ran Hong, an Argonne postdoctoral appointee on the study, "so to both control its motion and receive the data from the probes is very challenging."

To disturb the field as little as possible, only a single insulated signal cable connects the trolley to the outside world. This cable sends information to the trolley to guide it around the loop, and it sends the data from the probes back to the control room.

The older system used at Brookhaven for that laboratory's experiment sent the information using an analog signal, but Argonne scientists and engineers have digitized the signal to increase the amount of data obtained. "The access to more raw data allows for better analysis, and it has led to a 10-fold increase in precision," said Winter.

Because of the larger digital data set, the cable can only send information in one direction at a time. "We have to flip-flop between sending the trolley instructions and receiving the data," said Hong. "Around every 20 milliseconds, the direction switches."

The scientists have been setting up the Muon g-2 experiment for six years. This year, they will begin to take official data. The experiment will run for months, measuring the spin precession of approximately a trillion muons. Every two to three days, the experiment will pause to allow the trolley to measure the field, and smaller probes on the outside of the vacuum chamber will estimate the field at all times while the experiment runs.

"Unlike large-scale experiments that attempt to detect unknown particles directly, our approach is to search for indirect effects that change something at a very small scale," said Winter. "By very precisely measuring this factor, we can infer whether or not there is something new."

If the new data confirm the previous measurement, the scientists plan to conduct the experiment with even higher precision. Analysis of these new data could give a flavor of the nature of the new physics, and could indicate what detector would have to be constructed to observe the potential new particles directly. [14]

Muon machine makes milestone magnetic map

Muons are mysterious, and scientists are diving deep into the particle to get a handle on a property that might render it—and the universe—a little less mysterious.

Like electrons – muons' lighter siblings – they are particles with a sort of natural internal magnet. They also have an angular momentum called spin, kind of like a spinning top. The combination of the spin and internal magnet of a particle is called the gyromagnetic ratio, dubbed "g," but previous attempts at measuring it for muons have thrown up intriguing surprises.

The goal of the Muon g-2 experiment at Fermilab is to measure it more precisely than ever before.

To reach these remarkable levels of precision, scientists have to keep very careful tabs on a few parts of the experiment, one of which is how strong its magnetic field is. The team has been measuring and tweaking the magnetic field for months and is now very close to achieving a stable field before experiments can properly begin.

"We're in the experiment's commissioning period right now, where we're basically learning how our systems behave and making sure everything works properly before we transition into stable running," said David Flay, a University of Massachusetts scientist working on the calibration of the magnetic field for Muon g-2.

Muon mystery

Muon g-2 is following up on an intriguing result seen at Brookhaven National Laboratory in New York in the early 2000s, when the experiment made observations of muons that didn't match with theoretical predictions. The experiment's 15-meter-diameter circular magnet, called a storage ring, was shipped to Illinois across land and sea in 2013, and the measurement is now being conducted at Fermilab with four times the precision.

When Brookhaven carried out the experiment, the result was surprising: The muon value of g differed significantly from what calculations said it should be, and no one is quite sure why. It's possible the experiment itself was flawed and the result was false, but it also opens the door to the possibility of exotic new particles and theories. With its four-fold increase in precision, Muon g-2 will shed more light on the situation.

To measure g, beams of muons circulating inside the experiment's storage ring are subjected to an intense magnetic field – about 30,000 times the strength of Earth's natural field. This causes the muons to rotate around the magnetic field, or precess, in a particular way. By measuring this precession, it is possible to precisely extract the value of g.

The strength of magnetic field to which the muons are exposed directly affects how they precess, so it's absolutely crucial to make extremely precise measurements of the field strength and maintain its uniformity throughout the ring – not an easy task.

If Muon g-2 backs up Brookhaven's result, it would be huge news. The Standard Model would need rethinking and it would open up a whole new chapter of particle physics.

A leading theory to explain the intriguing results are new kinds of virtual particles, quantum phenomena that flit in and out of existence, even in an otherwise empty vacuum. All known particles do this, but their total effect doesn't quite account for Brookhaven's results. Scientists are therefore predicting one or more new, undiscovered kinds, whose additional ephemeral presence could be providing the strange muon observations.

"The biggest challenge so far has been dealing with the unexpected," said Joe Grange, scientist at Argonne National Laboratory working on Muon g-2's magnetic field. "When a mystery pops up that needs to be solved relatively quickly, things can get hectic. But it's also one of the more fun parts of our work."

Probing the field

The magnetic field strength measurements are made using small, sensitive electronic devices called probes. Three types of probes – fixed, trolley and plunging – work together to build up a 3-D map of the magnetic field inside the experiment. The field can drift over time, and things like temperature changes in the experiment's building can subtly affect the ring's shape, so roughly 400 fixed probes are positioned just above and below the storage ring to keep a constant eye on the field inside. Because these probes are always watching, the scientists know when and by how much to tweak the field to keep it uniform.

For these measurements, and every few days when the experiments is paused and the muon beam is stopped, a 0.5-meter-long, curved cylindrical trolley on rails containing 17 probes is sent around the ring to take a precise field map in the region where the muons are stored. Each orbit takes a couple of hours. The trolley probes are themselves calibrated by a plunging probe, which can move in and out of its own chamber at a specific location in the ring when needed.

The fixed probes have been installed and working since fall 2016, while the 17 trolley probes have recently been removed, upgraded and reinstalled.

"The probes are inside the ring where we can't see them," Flay said. "So matching up their positions to get an accurate calibration between them is not an easy thing to do."

The team developed some innovative solutions to tackle this problem, including a barcode-style system inside the ring, which the trolley scans to relay where it is as it moves around.

Global g-2

Muon g-2 is an international collaboration hosted by Fermilab. Together with scientists from Fermilab, Argonne, and Brookhaven, several universities across the U.S. work with international collaborators from countries as wide-ranging as South Korea, Italy and the UK. In total, around 30 institutions and 150 people work on the experiment.

"It's the detailed efforts of the Argonne, University of Washington, University of Massachusetts and University of Michigan teams that have produced these reliable, quality tools that give us a complete picture of the magnetic field," said Brendan Kiburg, Fermilab scientist working on Muon g-2. "It has taken years of meticulous work."

The team is working to finish the main field strength measurement part of the commissioning process by early 2018, before going on to analyze exactly how the muons experience the generated field. The experiment is planned to begin in full in February 2018. [13]

Relativity matters: Two opposing views of the magnetic force reconciled

Current textbooks often refer to the Lorentz-Maxwell force governed by the electric charge. But they rarely refer to the extension of that theory required to explain the magnetic force on a point particle. For elementary particles, such as muons or neutrinos, the magnetic force applied to such charges is unique and immutable. However, unlike the electric charge, the magnetic force strength is not quantised. For the magnetic force to act on them, the magnetic field has to be inhomogeneous. Hence this force is more difficult to understand in the context of particles whose speed is near the speed of light.

Moreover, our understanding of how a point-particle carrying a charge moves in presence of an inhomogenous magnetic field relied until now on two theories that were believed to differ. The first stems from William Gilbert's study of elementary magnetism in 16th century, while the second relies on André-Marie Ampère electric currents. In a new study just published in EPJ C, the authors Johann Rafelski and colleagues from the University of Arizona, USA, succeeded in resolving this ambiguity between Ameperian and Gilbertian forms of magnetic force. Their solution makes it possible to characterise the interaction of particles whose speed is close to the speed of light in the presence of inhomogeneous electromagnetic fields.

In the new study, the authors present, for the first time, an important insight into how magnetic field non-homogeneity impacts particle spin dynamics, called spin precession. No prior work has recognised the need to make the form of magnetic torque consistent with the form of magnetic force - the torque was made consistent only with the Lorentz-Maxwell force.

This advance allows the impact of field non-homogeneity on precision experiment to be quantified. It seeks to resolve a discrepancy in the understanding of quantum field corrections to the magnetic moment of the muon, an elementary particle often referred to as a "heavy electron."

These findings can be applied to the study of neutrinos, opening the door to realms beyond the standard model of particle physics. Rafelski and colleagues show that the magnetic force can be large for particles whose speed is very close to the speed of light. [12]

The color of magnets

Particle physics and decorative glassware are two disciplines that don't often meet. But given the striking results of a recent artist-scientist collaboration, perhaps that could change.

Artists Nathalie Kalbach and Urii Guchenia at the Chicagoland Nathalie Studio created stained-glass artwork as a representation of the magnetic field inside the Muon g-2 experiment at Fermilab. The centerpiece of Muon g-2 is a 15-meter-diameter ring-shaped magnet through which particles called muons shoot round at high speed.

To do the experiment, scientists have to keep the magnetic field throughout the whole ring extremely uniform and check it regularly so they can make tweaks. Earlier this year, the scientists took one of many measurements of just how uniform the field was. Slices from around the whole ring were squashed into a 2-D map, and it's this very map that is now immortalized in glass.

The different colors of glass represent the amount of imperfection in the field, with the red and blue areas showing the greatest nonuniformities. Although it looks as though there are huge variations in the field between the center and the edges, even the darkest colors in the map represent a discrepancy from the desired field strength of just two parts per million. And it's getting even better.

Stronger magnetic fields are shown in deeper colors. Credit: Ran Hong

"The map in glass is actually already outdated," said Muon g-2 scientist Ran Hong, scientist at Argonne National Laboratory who came up with the idea and owns the artwork. "We've since corrected for the nonuniformities at that level and are now getting it even more uniform."

The artwork saw attention from the public at Fermilab's 50th anniversary Open House when it was displayed in Muon g-2's building. It now hangs in Hong's office.

"If I cannot draw a physics concept in pictures, I don't think I understand it," said Hong. "When I or the public see a visualization, it gets rid of the math, and we can think more about the physics behind it and why it is the way it is."

Method to significantly enhance optical force

Light consists of a flow of photons. If two waveguides – cables for light – are side by side, they attract or repel each other. The interaction is due to the optical force, but the effect is usually extremely small. Physicists at Chalmers University of Technology and Free University of Brussels have now found a method to significantly enhance optical force. The method opens new possibilities within sensor technology and nanoscience. The results were recently published in Physical Review Letters.

To make light behave in a completely new way, the scientists have studied waveguides made of an artificial material to trick the photons. The specially designed material makes all the photons move to one side of the waveguide. When the photons in a nearby waveguide do the same, a collection of photons suddenly gather very closely. This enhances the force between the waveguides up to 10 times.

"We have found a way to trick the photons so that they cluster together at the inner sides of the waveguides. Photons normally don't prefer left or right, but our metamaterial creates exactly that effect," says Philippe Tassin, Associate Professor at the Department of Physics at Chalmers University of Technology.

Philippe Tassin and Sophie Viaene at Chalmers and Lana Descheemaeker and Vincent Ginis at Free University of Brussels have developed a method to use the optical force in a completely new way. It can, for example, be used in sensors or to drive nanomotors. In the future, such motors might be used to sort cells or separate particles in medical technology.

"Our method opens up new opportunities for the use of waveguides in a range of technical applications. It is really exciting that man-made materials can change the basic characteristics of light propagation so dramatically," says Vincent Ginis, assistant professor at the Department of Physics at
Free University of Brussels. [10]

Researchers demonstrate quantum teleportation of patterns of light

Nature Communications today published research by a team comprising Scottish and South African researchers, demonstrating entanglement swapping and teleportation of orbital angular momentum 'patterns' of light. This is a crucial step towards realizing a quantum repeater for high-dimensional entangled states.

Quantum communication over long distances is integral to information security and has been demonstrated in free space and fibre with two-dimensional states, recently over distances exceeding 1200 km between satellites. But using only two states reduces the information capacity of the photons, so the link is secure but slow. To make it secure and fast requires a higher-dimensional alphabet, for example, using patterns of light, of which there are an infinite number. One such pattern set is the orbital angular momentum (OAM) of light. Increased bit rates can be achieved by using OAM as the carrier of information. However, such photon states decay when transmitted over long distances, for example, due to mode coupling in fibre or turbulence in free space, thus requiring a way to amplify the signal. Unfortunately such "amplification" is not allowed in the quantum world, but it is possible to create an analogy, called a quantum repeater, akin to optical fibre repeaters in classical optical networks.

An integral part of a quantum repeater is the ability to entangle two photons that have never interacted - a process referred to as "entanglement swapping". This is accomplished by interfering two photons from independent entangled pairs, resulting in the remaining two photons becoming entangled. This allows the establishment of entanglement between two distant points without requiring one photon to travel the entire distance, thus reducing the effects of decay and loss. It also means that you don't have to have a line of sight between the two places.

An outcome of this is that the information of one photon can be transferred to the other, a process called teleportation. Like in the science fiction series, Star Trek, where people are "beamed" from one place to another, information is "teleported" from one place to another. If two photons are entangled and you change a value on one of them, then other one automatically changes too. This happens even though the two photons are never connected and, in fact, are in two completely different places.

In this latest work, the team performed the first experimental demonstration of entanglement swapping and teleportation for orbital angular momentum (OAM) states of light. They showed that quantum correlations could be established between previously independent photons, and that this could be used to send information across a virtual link. Importantly, the scheme is scalable to higher dimensions, paving the way for long-distance quantum communication with high information capacity.

Background

Present communication systems are very fast, but not fundamentally secure. To make them secure researchers use the laws of Nature for the encoding by exploiting the quirky properties of the quantum world. One such property is entanglement. When two particles are entangled they are connected in a spooky sense: a measurement on one immediately changes the state of the other no matter how far apart they are. Entanglement is one of the core resources needed to realise a quantum network.

Yet a secure quantum communication link over long distance is very challenging: Quantum links using patterns of light languish at short distances precisely because there is no way to protect the link against noise without detecting the photons, yet once they are detected their usefulness is destroyed. To overcome this one can have a repeating station at intermediate distances - this allows one to share information across a much longer distance without the need for the information to physically flow over that link. The core ingredient is to get independent photons to become entangled. While this has been demonstrated previously with two-dimensional states, in this work the team showed the first demonstration with OAM and in high-dimensional spaces. [9]

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]

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 $E = hv$ and $E = mc^2$, $m = hv /c^2$ that is the m depends only on the v 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

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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