Strongly Interacting Bose Polarons

Researchers have used impurities within a Bose-Einstein condensate to simulate polarons—electron-phonon combinations in solid-state systems. [15]

A team of engineering researchers from the University of Victoria (UVic) and the University of Rochester (UR) has developed a way to detect single molecules using a light-based technology inspired by the "whispering gallery" effect, first discovered in London's iconic St. Paul's Cathedral. [14]

Experiment suggests it might be possible to control atoms entangled with the light they emit by manipulating detection. [13]

Now, researchers have come up with a rather simple scheme for providing quantum error controls: entangle atoms from two different elements so that manipulating won't affect the second. Not only is this highly effective, the researchers show that they can construct quantum logic gates with the setup. And while they were at it, they demonstrate the quantum nature of entanglement with a precision that's 40 standard deviations away from classic physical behavior. [12]

A team of quantum physicists from Harvard University measured a property called entanglement entropy, which quantifies the apparent randomness that comes with observing just a portion of an entangled whole. Markus Greiner and colleagues used lasers to create an optical cage with four compartments, each of which held a rubidium atom chilled to nearly absolute zero. The researchers could tweak the laser settings to adjust the height of the walls between compartments. If the walls were low enough, atoms could exploit their strange quantum ability to occupy multiple compartments at once. As the four atoms jumped around, they interacted and established a state of entanglement. [11]

Physicists in the US and Serbia have created an entangled quantum state of nearly 3000 ultracold atoms using just one photon. This is the largest number of atoms ever to be entangled in the lab, and the researchers say that the technique could be used to boost the precision of atomic clocks. [10]

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.

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.

Contents

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Preface

Entanglement is a purely quantum-mechanical phenomenon that allows two or more particles to have a much closer relationship than is allowed by classical physics. One property of entangled particles is that they can be very sensitive to external stimuli such as a gravity or light, and therefore could be used to create precise "quantum sensors" and clocks. [10]

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. In a new proposed experiment in this area, two toaster-sized "nanosatellites" carrying entangled condensates orbit around the Earth, until one of them moves to a different orbit with different gravitational field strength. As a result of the change in gravity, the entanglement between the condensates is predicted to degrade by up to 20%. Experimentally testing the proposal may be possible in the near future. [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.

Bose Polarons that Strongly Interact

An electron moving through a solid-state crystal will attract nearby atoms in the lattice causing them to vibrate. This interaction was first studied in 1950 by Herbert Fröhlich who showed that this situation would give rise to a quasiparticle called a polaron, made up of the electron surrounded by a cloud of phonons, the quanta of acoustic vibration. The physical properties of the polaron, for instance its mobility or its effective mass, can be very different from those of the bare electron, leading to strong modifications of the electrical and thermal transport properties of the material. The problem is that even the simplest case, as described by Fröhlich's model, is too complex to be solved analytically, so approximations are often made. Researchers are thus trying to study polaron physics using analog systems consisting of gases of ultracold atoms. The results of these simulations provide insights into the underlying physics, as well as offer verification for the approximations made in polaron models.

In two independent works, groups from Denmark and Colorado have demonstrated an atomic implementation of polaronic physics by immersing an impurity inside a Bose-Einstein condensate. The impurity interacts with the condensate in a way that is similar to an electron in a crystal. Since, like solids, the low-energy modes of a Bose-Einstein condensate (BEC) are phonons, this system can be described by Fröhlich's model in the regime of weak interactions. But by tuning the strength of interactions, the research teams could also access the regime of strong interaction between the impurity and the BEC, revealing the influence of many-body correlations. The strongly interacting regime of Bose polarons is largely an unchartered territory that may provide insight into superfluid physics, such as in superconductors and liquid helium.

Both these works build on decade-old studies that used ultracold atomic systems to study the fermionic polaron, which is an impurity interacting with an ensemble of spin-polarized fermions [4]. These fermions obey the Pauli principle, which prevents two or more identical fermions from being at the same place. This principle does not apply to bosons, which makes the case of bosonic polarons more challenging, both theoretically and experimentally. Unlike in a Fermi gas, a Bose gas allows interactions between three atoms. These three-body correlations are both a blessing and a curse. On the one hand, they lead to fascinating physical phenomena, such as the celebrated Efimov bound states, a family of universal trimers existing even in the absence of two-body bound states . On the other hand, they allow the formation of bound molecules that effectively remove atoms from the gas. These three-body recombination losses can reduce significantly the lifetime of the polaron system in the strongly interacting regime.

To reduce the effect of these losses during their measurement, the two groups have used a scheme previously developed for the study of fermionic polarons.

They first prepared the impurity in a spin state that essentially doesn't interact with the surrounding condensate. Then, using a short radio frequency pulse, they flipped the spin of the impurity, placing it in a spin state that interacts with the condensate. In their experiment, Ming-Guang Hu and colleagues from the University of Colorado, Boulder, added impurities in the form of potassium atoms to a BEC of rubidium atoms. Nils Jørgensen from Aarhus University, Denmark, and his colleagues actually create the impurities with the radio frequency pulse. They start with a potassium BEC and then use the radio frequency pulse to excite a small fraction of potassium atoms in another spin state, which makes them behave as impurities.

In ultracold-atom systems, it is possible to tune the interaction strength between atoms using an external magnetic field owing to the Fano-Feshbach resonance phenomenon. Using this tool, the two groups varied the interaction between the impurity and the surrounding BEC. As the interaction was made stronger, it altered the resonance condition for the spin flip used to turn on the interactions. Both teams measured this resonance shift by varying the radio frequency of their pulses and observing where the peak occurred in the absorption spectrum. The shifts in the spectra were consistent with the impurities behaving as polarons.

The Boulder group observed that the absorption peaks broadened as the interaction strength increased. They argue that these widths could be used to determine the polaron lifetime once other broadening effects are accounted for. They also imagine that future work could observe the polaron's effective mass and how it depends on the interaction strength.

To interpret their data, the Danish experimentalists teamed up with theoreticians at Aarhus University and Monash University in Australia, who have developed advanced theoretical methods capable of capturing the three-body correlations. They showed that their radio spectroscopy data were not affected by three-body recombinations and that they could obtain a remarkably good quantitative agreement with experiment. They proved that, as expected, Fröhlich's model provided an accurate description of the system in the weakly attractive and repulsive regimes, but they also demonstrated the importance of three-body correlations in the strongly interacting regime.

These works pave the way for further studies of strongly correlated Bose gases that would bridge the gap between the physics of ultracold vapors and that of denser systems, like solids or liquid helium mixtures.

This research is published in Physical Review Letters. [15]

Optical spring detects single molecules

A team of engineering researchers from the University of Victoria (UVic) and the University of Rochester (UR) has developed a way to detect single molecules using a light-based technology inspired by the "whispering gallery" effect, first discovered in London's iconic St. Paul's Cathedral.

The new technology, described in a study published today in the peer-reviewed journal, Nature Communications, has many potential applications, including medical diagnostics, drug development, security screening and environmental science.

"The ability to detect a single molecule or nanoparticle is essential for many applications," says Wenyan Yu, a PhD student and one of the paper's authors along with photonic engineer Tao Lu of UVic, and optical engineers Wei Jiang and Qiang Lin of UR. "To date, many approaches have been used to observe single particles. Our discovery may allow scientists the ability to detect particles as miniscule as a single atom, or a single base pair of DNA."

The whispering gallery of St. Paul's Cathedral in London is an acoustic marvel. When a person whispers against one wall, the voice travels around the chamber's circular rim and is clearly audible over 34 metres away on the other side. A "whispering gallery microcavity" is a kind of gallery-in-miniature, typically 100 microns in diameter—about the width of a human hair—in which waves of light, rather than sound, can be confined in a microstructure.

Light circulating inside the cavity produces a force that makes the cavity vibrate, or quiver, creating the so-called optical spring effect. The research team discovered that when an individual particle or biomolecule lands on the surface of quivering microcavity, the optical spring force changes the vibration in a particular and measurable way.

"Although the optical spring effect has been known for more than a decade," says Wei Jiang, "this discovery significantly enhances the sensitivity of the device."

Lu and the team are now refining the detection sensitivity and says eventually it could be used to detect specific protein molecules to diagnose cancer at an early stage, or to find out whether a drug interacts with single biomolecules.

The UVic team fabricated the devices, prepared the samples, conceived, designed and performed the experiments, and processed the data. The UR team discovered the sensing principle and mechanism, developed the theory, and conducted the numerical simulation. The teams worked together on the analysis and interpretation. [14]

Experiment suggests it might be possible to control atoms entangled with the light they emit by manipulating detection

Flick a switch on a dark winter day and your office is flooded with bright light, one of many everyday miracles to which we are all usually oblivious.

A physicist would probably describe what is happening in terms of the particle nature of light. An atom or molecule in the fluorescent tube that is in an excited state spontaneously decays to a lower energy state, releasing a particle called a photon. When the photon enters your eye, something similar happens but in reverse. The photon is absorbed by a molecule in the retina and its energy kicks that molecule into an excited state.

Light is both a particle and a wave, and this duality is fundamental to the physics that rule the Lilliputian world of atoms and molecules. Yet it would seem that in this case the wave nature of light can be safely ignored.

Kater Murch, assistant professor of physics in Arts & Sciences at Washington University in St. Louis, might give you an argument about that. His lab is one of the

first in the world to look at spontaneous emission with an instrument sensitive to the wave rather than the particle nature of light, work described in the May 20th issue of Nature Communications

. His experimental instrument consists of an artificial atom (actually a superconducting circuit with two states, or energy levels) and an interferometer, in which the electromagnetic wave of the emitted light interferes with a reference wave of the same frequency.

This manner of detection turns everything upside down, he said. All that a photon detector can tell you about spontaneous emission is whether an atom is in its excited state or its ground state. But the interferometer catches the atom diffusing through a quantum "state space" made up of all the possible combinations, or superpositions, of its two energy states.

This is actually trickier than it sounds because the scientists are tracking a very faint signal (the electromagnetic field associated with one photon), and most of what they see in the interference pattern is quantum noise. But the noise carries complementary information about the state of the artificial atom that allows them to chart its evolution.

When viewed in this way, the artificial atom can move from a lower energy state to a higher energy one even as its follows the inevitable downward trajectory to the ground state. "You'd never see that if you were detecting photons," Murch said.

So different detectors see spontaneous emission very differently. "By looking at the wave nature of light, we are able see this lovely diffusive evolution between the states," Murch said.

But it gets stranger. The fact that an atom's average excitation can increase even when it decays is a sign that how we look at light might give us some control over the atoms that emitted the light, Murch said.

This might sound like a reversal of cause and effect, with the effect pushing on the cause. It is possible only because of one of the weirdest of all the quantum effects: When an atom emits light, quantum physics requires the light and the atom to become connected, or entangled, so that measuring a property of one instantly reveals the value of that property for the other, no matter how far away it is.

Or put another way, every measurement of an entangled object perturbs its entangled partner. It is this quantum back-action, Murch said, that could potentially allow a light detector to control the light emitter.

"Quantum control has been a dream for many years," Murch said. "One day, we may use it to enhance fluorescence imaging by detecting the light in a way that creates superpositions in the emitters.

"That's very long term, but that's the idea," he said. [13]

Two atoms make quantum memory, processing gate, and test of entanglement

Quantum systems are inherently fragile as any interactions with the outside world can change their state. That makes creating things like quantum memories rather challenging, since it can be hard to know if it actually preserves the information you put into it. To get around this, researchers have been looking into ways of creating error-correcting quantum memory.

Now, researchers have come up with a rather simple scheme for providing quantum error controls: entangle atoms from two different elements so that manipulating won't affect the second. Not only is this highly effective, the researchers show that they can construct quantum logic gates with the setup. And while they were at it, they demonstrate the quantum nature of entanglement with a precision that's 40 standard deviations away from classic physical behavior.

People have managed to entangle different types of particles previously. For example, you can entangle an atom and a photon, which allows the photon to transfer information elsewhere—something that's undoubtedly necessary for a quantum computer.

In the two new papers, the researchers involved lay out the case for entangling different types of atoms. If you use the same types of atoms for memory and backup copies of the bits, then there's always a chance that a photon meant for the memory will scatter off it and hit one of the backups instead. If you use atoms from different elements, then they'll be sensitive to different wavelengths of light. Manipulating one will leave the other unaffected.

As one of the labs involved (from the University of Oxford) put it, "it allows protection of memory qubits while other qubits undergo logic operations or are used as photonic interfaces to other processing units."

The Oxford team went about this by using two different isotopes of calcium. A second team, from the National Institute of Standards and Technology and the University of Washington, used entirely different atoms (beryllium and magnesium). The calcium atoms could maintain their state for roughly a minute, while the beryllium atoms would hold state for a second and a half, making them somewhat stable in qubit terms.

Both teams confirm that their two atoms are entangled with a very high probability; .998 for one, .979 for the other (of a maximum of one). The NIST team even showed that it could track the beryllium atom as it changed state by observing the state of the magnesium atom. [12]

Spooky quantum connection quantified for multiple particles

A first-of-its-kind measurement has quantified a mysterious quantum bond shared by several particles rather than just two. The experiment, reported in the Dec. 3 Nature, brings physicists closer to understanding the true scope of this link, known as quantum entanglement.

Entanglement interweaves particles' fates so that some of each particle's properties, which are inherently uncertain according to quantum mechanics, are tied to those of its partners. Each particle essentially sacrifices its individuality to become part of an umbrella entangled state. While physicists have developed reliable methods for detecting entanglement between pairs of particles, the measurements get tricky when three or more particles are involved.

A team of quantum physicists from Harvard University measured a property called entanglement entropy, which quantifies the apparent randomness that comes with observing just a portion of an entangled whole. Markus Greiner and colleagues used lasers to create an optical cage with four compartments, each of which held a rubidium atom chilled to nearly absolute zero. The researchers could tweak the laser settings to adjust the height of the walls between compartments. If the walls were low enough, atoms could exploit their strange quantum ability to occupy multiple compartments at once. As the four atoms jumped around, they interacted and established a state of entanglement.

Greiner's team created a pair of four-compartment systems and confirmed that they were identical using a technique developed for comparing photons. Then the researchers compared portions of the two cages — say, two of the four compartments where atoms could reside. The partial system of one cage differed from the corresponding partial system of the other cage. A difference between parts when the wholes are indistinguishable "only happens if there is entanglement within each system," Greiner says.

Peter Zoller, a theoretical quantum physicist at the University of Innsbruck in Austria, says that while studying entangled particle pairs is interesting, the real world is dominated by entangled states that encompass much larger sets of particles. Analyzing particles in collections similar to those in Greiner's experiment could help physicists understand the complex entanglement-rich interactions between electrons in superconductors, which conduct electrical current with no resistance. [11]

How to entangle nearly 3000 atoms using a single photon

Until this latest experiment by Vladan Vuletić and colleagues at the Massachusetts Institute of Technology and the University of Belgrade, physicists had managed to entangle about 100 atoms within a much larger ensemble of atoms. Now, Vuletić's team has managed to entangle nearly 94% of the atoms in its ensemble of 3100 atoms.

The experiment involves an optical cavity – two opposing imperfect mirrors – containing about 3100 rubidium-87 atoms that are cooled to a temperature of near absolute zero. Light is shone into one side of the cavity and allowed to bounce back and forth between the mirrors. Some of the light will eventually escape through the opposite side of the cavity, where it is captured by a detector. A magnetic field is applied to the atoms, which causes them to align their spins along the length of the cavity. However, the probabilistic nature of quantum mechanics means that the spins are not all aligned and their directions will fluctuate about the magnetic field.

Preliminary experiment

These fluctuations were measured in a preliminary experiment that involves firing a pulse of polarized light into the cavity. The pulse interacts with the atomic spins and emerges from the cavity with a small change or rotation of its polarization. This rotation is a measure of the direction of the total atomic spin of the gas relative to the direction of the magnetic field. By making this measurement many times over, the team showed that the total atomic spin in the cavity has a Gaussian distribution that is a disc centered on the direction of the applied magnetic field.

This representation of the total spin is called a "Wigner function" and it illustrates how the probabilistic nature of quantum mechanics causes fluctuations in the direction of the total spin. However, the fact that the function is Gaussian means that the atomic spins are behaving independently of each other and are not entangled. Therefore, the challenge for the researchers was to prepare the atoms in such a way that the Wigner function becomes non-Gaussian – which is strong evidence for entanglement.

To do this they fired an extremely weak polarized laser pulse into the cavity. Occasionally, just one photon in the pulse will bounce back and forth in the cavity and interact with nearly all of the atomic spins. This succession of interactions is what entangles the atoms.

Heralding entanglement

This photon can then leave the cavity and be detected. Such entangling photons are identifiable because their polarizations have been rotated by 90° by the atomic interactions. So, whenever such a "herald" photon was detected, the physicists immediately measured the direction of the total atomic spin. They repeated this process many times over to determine the Wigner function of the entangled atoms. Instead of a Gaussian disc, the distribution resembled a ring of positive probability surrounding an inner region of negative probability.

According to Vuletić, this hole of negative probability is the hallmark of entanglement. Furthermore, the researchers were able to calculate that the entanglement involved about 2910 of the 3100 atoms. In this experiment, the atomic spins were entangled in two states that lie on opposing sides of the hole of negative probability.

Vuletić says that the research has important practical applications because the Wigner function is essentially a measure of the uncertainty in a quantum measurement. By entangling large numbers of atoms and effectively "punching a hole" in the centre of the Wigner function, the precision of a quantum measurement can be improved. He told physicsworld.com that his team is now using the entanglement technique to create a more precise atomic clock. [10]

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]

Quantum Biology

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems.

Quantum Consciousness

Extensive scientific investigation has found that a form of quantum coherence operates within living biological systems through what is known as biological excitations and biophoton emission. What this means is that metabolic energy is stored as a form of electromechanical and electromagnetic excitations. These coherent excitations are considered responsible for generating and maintaining long-range order via the transformation of energy and very weak electromagnetic signals. After nearly twenty years of experimental research, Fritz-Albert Popp put forward the hypothesis that biophotons are emitted from a coherent electrodynamics field within the living system.

What this means is that each living cell is giving off, or resonating, a biophoton field of coherent energy. If each cell is emitting this field, then the whole living system is, in effect, a resonating field-a ubiquitous nonlocal field. And since biophotons are the entities through which the living system communicates, there is near-instantaneous intercommunication throughout. And this, claims Popp, is the basis for coherent biological organization -- referred to as quantum coherence. This discovery led Popp to state that the capacity for evolution rests not on aggressive struggle and rivalry but on the capacity for communication and cooperation. In this sense the built-in capacity for species evolution is not based on the individual but rather living systems that are interlinked within a coherent whole: Living systems are thus neither the subjects alone, nor objects isolated, but both subjects and objects in a mutually communicating universe of meaning. . . . Just as the cells in an organism take on different tasks for the whole, different populations enfold information not only for themselves, but for all other organisms, expanding the consciousness of the whole, while at the same time becoming more and more aware of this collective consciousness.

Quantum Cognition

Human Perception

A Bi-stable perceptual phenomenon is a fascinating topic in the area of perception. If a stimulus has an ambiguous interpretation, such as a Necker cube, the interpretation tends to oscillate across time. Quantum models have been developed to predict the time period between oscillations and how these periods change with frequency of measurement. Quantum theory has also been used for modeling Gestalt perception, to account for interference effects obtained with measurements of ambiguous figures. [6]

Human memory

The hypothesis that there may be something quantum-like about the human mental function was put forward with “Spooky Activation at Distance” formula which attempted to model the effect that when a word’s associative network is activated during study in memory experiment, it behaves like a quantum-entangled system. Models of cognitive agents and memory based on quantum collectives have been proposed by Subhash Kak. But he also points to specific problems of limits on observation and control of these memories due to fundamental logical reasons. [6]

Knowledge representation

Concepts are basic cognitive phenomena, which provide the content for inference, explanation, and language understanding. Cognitive psychology has researched different approaches for understanding concepts including exemplars, prototypes, and neural networks, and different fundamental problems have been identified, such as the experimentally tested non classical behavior for the conjunction and disjunction of concepts, more specifically the Pet-Fish problem or guppy effect, and the overextension and under extension of typicality and membership weight for conjunction and disjunction. By and large, quantum cognition has drawn on quantum theory in three ways to model concepts.

Exploit the contextuality of quantum theory to account for the contextuality of concepts in cognition and language and the phenomenon of emergent properties when concepts combine.

Use quantum entanglement to model the semantics of concept combinations in a non-decompositional way, and to account for the emergent properties/associates/inferences in relation to concept combinations.

Use quantum superposition to account for the emergence of a new concept when concepts are combined, and as a consequence put forward an explanatory model for the Pet-Fish problem situation, and the overextension and under extension of membership weights for the conjunction and disjunction of concepts. The large amount of data collected by Hampton on the combination of two concepts can be modeled in a specific quantum-theoretic framework in Fock space where the observed deviations from classical set (fuzzy set) theory, the above mentioned over- and under-extension of membership weights, are explained in terms of contextual interactions, superposition, interference, entanglement and emergence. And, more, a cognitive test on a specific concept combination has been performed which directly reveals, through the violation of Bell’s inequalities, quantum entanglement between the component concepts. [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." [9]

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.
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]

Dark Matter and Energy

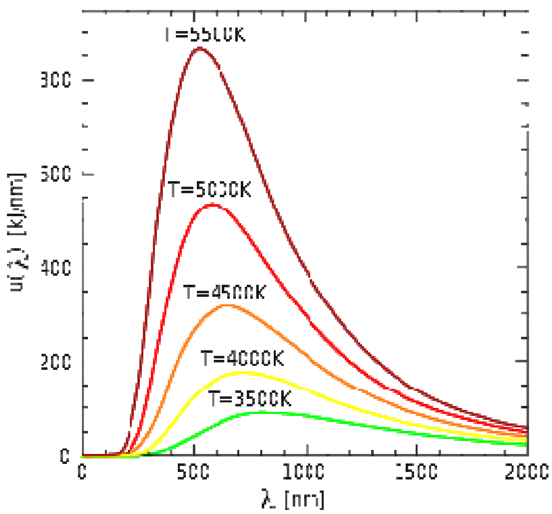
Dark matter is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant level. It is otherwise hypothesized to simply be matter that is not reactant to light. Instead, the existence and properties of dark matter are inferred from its gravitational effects on visible matter, radiation, and the large-scale structure of the universe. According to the Planck mission team, and based on the standard model of cosmology, the total mass–energy of the known universe contains 4.9% ordinary matter, 26.8% dark matter and 68.3% dark energy. Thus, dark matter is estimated to constitute 84.5% of the total matter in the universe, while dark energy plus dark matter constitute 95.1% of the total content of the universe. [6]

Cosmic microwave background

The cosmic microwave background (CMB) is the thermal radiation assumed to be left over from the "Big Bang" of cosmology. When the universe cooled enough, protons and electrons combined to form neutral atoms. These atoms could no longer absorb the thermal radiation, and so the universe became transparent instead of being an opaque fog. [7]

Thermal radiation

Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter. All matter with a temperature greater than absolute zero emits thermal radiation. When the temperature of the body is greater than absolute zero, interatomic collisions cause the kinetic energy of the atoms or molecules to change. This results in charge-acceleration and/or dipole oscillation which produces electromagnetic radiation, and the wide spectrum of radiation reflects the wide spectrum of energies and accelerations that occur even at a single temperature. [8]



Conclusions

According to Vuletić, this hole of negative probability is the hallmark of entanglement. Furthermore, the researchers were able to calculate that the entanglement involved about 2910 of the 3100 atoms. In this experiment, the atomic spins were entangled in two states that lie on opposing sides of the hole of negative probability. [10]

The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]

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]

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 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. 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. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter. Since the dark matter not participating in the diffraction patterns, also cannot be part of quantum entanglement, because of this we haven't information about it, we conclude its existence from its gravitational effect only.

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