

# Quantum Detection of Nuclear Spins

*Researchers at the University of Melbourne have demonstrated a way to detect nuclear spins in molecules non-invasively, providing a new tool for biotechnology and materials science. [16]*

*Precision measurement on heavy ions contradicts theory of interaction between atomic nucleus and electron. [15]*

*For the first time, scientists have succeeded in studying the strength of hydrogen bonds in a single molecule using an atomic force microscope. [14]*

*International team solves mystery of colloidal chains. [13]*

*An international team of researchers have found evidence of a mysterious new state of matter, first predicted 40 years ago, in a real material. This state, known as a quantum spin liquid, causes electrons - thought to be indivisible building blocks of nature - to break into pieces. [12]*

*In a single particle system, the behavior of the particle is well understood by solving the Schrödinger equation. Here the particle possesses wave nature characterized by the de Broglie wave length. In a many particle system, on the other hand, the particles interact each other in a quantum mechanical way and behave as if they are "liquid". This is called quantum liquid whose properties are very different from that of the single particle case. [11]*

*Quantum coherence and quantum entanglement are two landmark features of quantum physics, and now physicists have demonstrated that the two phenomena are "operationally equivalent"—that is, equivalent for all practical purposes, though still conceptually distinct. This finding allows physicists to apply decades of research on entanglement to the more fundamental but less-well-researched concept of coherence, offering the possibility of advancing a wide range of quantum technologies. [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.*

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## Preface

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.

## **Quantum probes dramatically improve detection of nuclear spins**

Researchers at the University of Melbourne have demonstrated a way to detect nuclear spins in molecules non-invasively, providing a new tool for biotechnology and materials science.

Important research in medicine and biology relies on nuclear magnetic resonance (NMR) spectroscopy, but until now, it has been limited in spatial resolution and typically requires powerful microwave fields. A team led by Professor Lloyd Hollenberg at the University of Melbourne has used a quantum probe to perform microwave-free NMR at the nanoscale. The results were published today in Nature Communications.

"This quantum probe delivers a dramatic improvement in NMR technology. In addition to being able to detect NMR in far smaller samples than conventional machines, our technique does not require the application of microwave fields that might disrupt biological samples" said Hollenberg, who is Deputy Director of the Centre for Quantum Computation and Communication Technology (CQC2T) and Thomas Baker Chair at the University of Melbourne.

"In NMR the goal is to detect the magnetic signal from the nuclei of the atoms comprising molecules. But the signal from the nuclear "spin" is very weak and conventional NMR machines require many millions of nuclear spins to detect anything. However, using the quantum properties of a 'defect' in diamond, our technique can detect much smaller volumes down to only thousands of spins."

The discovery may overcome significant limitations with conventional NMR methods, which depend on machines that can exceed 10 tonnes.

"The problem with the large NMR machines in widespread use today is that the signals we're trying to detect are extremely small, and the distance from the measurement device to the object being measured is very large," said Dr. Alastair Stacey, a CQC2T postdoctoral researcher.

"This creates two problems: The machine can only see a larger collection of molecules, reducing the accuracy of the measurement. It also has to use very strong microwaves and magnetic fields to reach the sample, but these processes are invasive and can affect delicate bio-samples, just like the microwave in your kitchen, particularly when trying to see the molecular structure of liquids."

Lead author James Wood describes the technique as "a dramatic simplification of the nuclear detection process, where we essentially shine light on an atomic-sized defect in diamond and observe its natural response, at a fundamentally quantum level, to the target nuclear spins nearby".

"A great benefit of our approach is that we don't interfere with the sample when imaging it."

The technique offers new opportunities for researchers.

"With these advances in quantum sensing technology, we are opening the door to a new world of scientific investigation that could lead us to gain a better understanding of the smallest building blocks of life," said Hollenberg. [16]

## **Precision measurement on heavy ions contradicts theory of interaction between atomic nucleus and electron**

For the first time, a team of researchers under the leadership of TU Darmstadt has succeeded in measuring the transition between energy levels of the lithium-like ions of bismuth with such precision that it has become possible to reassess underlying theories. This has led to a surprising result—the understanding of the interaction between an electron and an atomic nucleus that we have had until now might be erroneous.

At the surface of the nuclei of bismuth atoms, magnetic fields exist which are otherwise only present at the surface of massive neutron stars. The behaviour of electrons in these fields has been investigated by a group of researchers under the leadership of Technische Universität Darmstadt. Only recently have they achieved a breakthrough by observing for the first time a special transition in lithium-like ions of this element.

They have now succeeded in measuring this transition at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt with such precision that it was possible for the first time to reassess the underlying theory convincingly. In the latest issue of the specialist journal *Nature Communications*, the scientists give an account of their surprising result: the discrepancy between the theory and the experiment is striking. It suggests an error in our understanding of how an electron interacts with the complex inner structure of a nucleus.

Simple atoms consisting of a single nucleus and one or a few electrons are ideal systems to check our understanding of the underlying physical forces at stake. We have a better grasp of the theory of the atom's electron shell based on quantum electrodynamics (QED) than of the actual structure of the atomic nucleus. QED allows the properties of the electrons and the states in which the atom can exist to be calculated with great accuracy. These calculations are then checked by means of precision measurements. To date, QED has passed all these tests with flying colors.

When using heavy nuclei, the scientists are mainly interested in the influence of the gigantic electric and magnetic fields on the electrons bound in the shell. Only very few experimental verifications of this theory have been carried out under these extreme conditions, and they do not – by far – exhibit the same accuracy as the experiments performed with light nuclei. The strong fields make the theoretical calculations much more difficult. In addition, the complex inner structure of the nuclei is not known with sufficient precision although it has a strong influence on the atomic shell.

Precision measurement on heavy ions contradicts theory of interaction between atomic nucleus and electron

Storage Ring ESR – Exterior View. Credit: J. Mai, GSI Helmholtzzentrum für Schwerionenforschung

In order to by-pass this difficulty, theoreticians calculate certain differences for systems with different numbers of electrons, but with the same atomic nucleus. These so-called "specific differences" are of such a nature that the contributions of the nucleus' structure should eliminate themselves almost exactly and that they can be used by the researchers as a starting point to check the QED calculations with more precision. The results that have now been published, however, seem to question the concept of specific difference.

### Research at the Storage Ring ESR

In its experiment, the team first generated hydrogen-like and lithium-like bismuth ions. These ions were injected into the experimental storage ring (ESR) at the GSI accelerator facility which has a circumference of 108 m and is equipped with two straight sections where experiments can be carried out. In one of those sections, an electron beam of defined energy is superimposed with the ion beam. After a few seconds, the ions' speed adjusts to that of the electrons. In this section, a pulsed laser beam is, in addition, superimposed with the ion beam. The laser's wavelength is then modified in tiny increments. When the laser reaches exactly the wavelength of the transition of the ion to be investigated, the ions absorb light particles (photons) – and thus energy – from the laser beam. Ions that are excited in this way release this energy after a short while, thereby emitting a very small number of photons.

This small number of photons was efficiently detected by means of a special mirror and single-photon detection system which was developed at the University of Münster. Due to the high speed, the wavelength of the laser is compressed or stretched by a factor of approximately 2.4, for a counterpropagating or a copropagating laser, respectively. This factor depends on the accelerating voltage of the electrons. To measure this high voltage of approximately 214,000 volts with an accuracy on the order of 1 V, a high-voltage divider developed at PTB in Braunschweig was used. Scientists from TU Darmstadt were responsible, among other things for the data acquisition and the time-dependent synchronisation of the laser pulses, which only last a few billionths of a second (nanoseconds) with the revolution of the ions inside the storage ring. They also analyzed the data.

The specific difference in the transition wavelengths measured in hydrogen-like and lithium-like bismuth does not agree with the theoretical prediction, even when taking all known sources of systematic errors into consideration. The cause for this deviation is not known yet and is to be investigated within the scope of further measurements with other isotopes of bismuth. These isotopes are, however, radioactive and must therefore be produced before being injected into the storage ring. These possibilities are available at the GSI Helmholtzzentrum. The new accelerator facility, FAIR, whose construction in Darmstadt will soon begin, will provide new possibilities for further investigations of this subject. [15]

## Hydrogen bonds directly detected for the first time

For the first time, scientists have succeeded in studying the strength of hydrogen bonds in a single molecule using an atomic force microscope. Researchers from the University of Basel's Swiss Nanoscience Institute network have reported the results in the journal *Science Advances*.

Hydrogen is the most common element in the universe and is an integral part of almost all organic compounds. Molecules and sections of macromolecules are connected to one another via hydrogen atoms, an interaction known as hydrogen bonding. These interactions play an important role in nature, because they are responsible for specific properties of proteins or nucleic acids and, for example, also ensure that water has a high boiling temperature.

To date, it has not been possible to conduct a spectroscopic or electron microscopic analysis of hydrogen and the hydrogen bonds in single molecules, and investigations using atomic force microscopy have also not yielded any clear results.

Dr. Shigeki Kawai, from Professor Ernst Meyer's team at the Swiss Nanoscience Institute and the Department of Physics at the University of Basel, has now succeeded in using a high-resolution atomic force microscope to study hydrogen atoms in individual cyclic hydrocarbon compounds.

## Choosing the right molecules for a clear view

In close collaboration with colleagues from Japan, the researchers selected compounds whose configuration resembles that of a propeller. These propellanes arrange themselves on a surface in such a way that two hydrogen atoms always point upwards. If the tip of the atomic force microscope, which is functionalized with carbon monoxide, is brought close enough to these hydrogen atoms, hydrogen bonds are formed that can then be examined.

Hydrogen bonds are much weaker than chemical bonds, but stronger than intermolecular van der Waals interactions. The measured forces and distances between the oxygen atoms at the tip of the atomic force microscope and the propellane's hydrogen atoms correspond very well to the calculations performed by Prof. Adam S. Foster from Aalto University in Finland. They show that the interaction clearly involves hydrogen bonds. The measurements mean that the much weaker van der Waals forces and the stronger ionic bonds can be excluded.

With this study, the researchers from the University of Basel's Swiss Nanoscience Institute network have opened up new ways to identify three-dimensional molecules such as nucleic acids or polymers via observation of hydrogen atoms. [14]

## Team solves mystery of colloidal chains

When Northwestern Engineering's Erik Luijten met Zbigniew Rozynek, they immediately became united by a mystery.

Presenting at a conference in Norway, Rozynek, a researcher at Adam Mickiewicz University in Poznan, Poland, demonstrated something that looked almost like magic. When he poked a needle-shaped electrode into a mixture of micron-sized, spherical metal particles dispersed in silicone oil, a sphere stuck to its end. As Rozynek pulled the electrode out of the dispersion, another sphere

attached to the first sphere, and then another to the second sphere, and so on, until a long chain formed.

"The spheres behaved like magnetic beads, except no magnetism was involved," said Luijten, professor of materials science and engineering and of engineering and applied mathematics at Northwestern's McCormick School of Engineering. "The particles have no tendency to cluster. I realized that something more complicated was happening."

Rozynek, along with his collaborators Filip Dutka, Piotr Garstecki, and Arkadiusz Józefczak, and Luijten joined their teams to understand the phenomenon that caused these chains to form. Their resulting discovery could lead to a new generation of electronic devices and a fast, simple method to write two-dimensional electronic circuits.

"Our scientific results could open up other areas for future research—both fundamental and applied," Rozynek said. "We are already working on follow-up projects based on our discovery."

Supported by the Foundation for Polish Science, Polish National Science Centre, and the US National Science Foundation, the research was published online today in the journal *Nature Communications*. Rozynek and Luijten are co-corresponding authors. Rozynek is also co-first author with Ming Han, a PhD student in Luijten's Computational Soft Matter Lab.

Rozynek and Han performed multiple calculations, showing how the electrode's electric field changed the particles' properties. When the electrode is dipped into the colloidal solution, its charged tip polarizes each sphere. These induced dipolar interactions cause the spheres to link together. A resulting chain could contain hundreds of thousands of spheres, reaching up to 30 centimeters in length.

After the team solved the mystery of how the chains formed, it had a second mystery to tackle. "Another fascinating part is that once we pulled the chain out of the liquid, we no longer had to apply an electric field to hold the chain's structure," Han said. "After the field was turned off, the stable particle chain remained stable."

Following months of investigation, Luijten and Rozynek's teams discovered that the chains maintained their structures due to liquid "bridges" between adjacent particles. As researchers pulled the chain out of the liquid, silicone oil clung to the sides of each particle, forming a case around the entire chain and keeping it intact.

"Surface tension plays a big role here," Han said. "The liquid bridge made the particles stick together. The physics here is really interesting. Most people would think that if you wanted to hold the structure, then you would need to apply the electric field. But that is not needed in our system."

Once the flexible chain is pulled out of the liquid, it can be immediately dragged along a surface and deposited to create a pattern. The researchers believe this method could be used as an alternative way to create simple, two-dimensional electronic circuits. If molten wax is used instead of silicone oil, then the method could also be used to build three-dimensional structures that hold their shapes when the wax cools and hardens.



"Though simple, our method for fabricating colloidal structures is very elegant and can be used for many applications," Rozynek said, "including fabrication of conductive paths on different substrates to be used, for example, in electronic applications."

Luijten and Rozynek believe that solving this mystery could potentially open the door for applications that they cannot predict today. By understanding how the method works, they can better assess how different types of fluids or voltage levels could affect the chains and change the outcome.

"Understanding how it works makes it so much easier to manipulate and optimize," Luijten said. "We can say if the method will work better or worse if the particles are larger or if the electric field is stronger. That's only possible because we understand it. Otherwise, you would have to examine an endless set of combinations." [13]

## **New state of matter detected in a two-dimensional material**

The researchers, including physicists from the University of Cambridge, measured the first signatures of these fractional particles, known as Majorana fermions, in a two-dimensional material with a structure similar to graphene. Their experimental results successfully matched with one of the main theoretical models for a quantum spin liquid, known as a Kitaev model. The results are reported in the journal *Nature Materials*.

Quantum spin liquids are mysterious states of matter which are thought to be hiding in certain magnetic materials, but had not been conclusively sighted in nature.

The observation of one of their most intriguing properties—electron splitting, or fractionalisation—in real materials is a breakthrough. The resulting Majorana fermions may be used as building blocks of quantum computers, which would be far faster than conventional computers and would be able to perform calculations that could not be done otherwise.

"This is a new quantum state of matter, which has been predicted but hasn't been seen before," said Dr Johannes Knolle of Cambridge's Cavendish Laboratory, one of the paper's co-authors.

In a typical magnetic material, the electrons each behave like tiny bar magnets. And when a material is cooled to a low enough temperature, the 'magnets' will order themselves, so that all the north magnetic poles point in the same direction, for example.

But in a material containing a spin liquid state, even if that material is cooled to absolute zero, the bar magnets would not align but form an entangled soup caused by quantum fluctuations.

"Until recently, we didn't even know what the experimental fingerprints of a quantum spin liquid would look like," said paper co-author Dr Dmitry Kovrizhin, also from the Theory of Condensed Matter group of the Cavendish Laboratory. "One thing we've done in previous work is to ask, if I were performing experiments on a possible quantum spin liquid, what would I observe?"

Knolle and Kovrizhin's co-authors, led by the Oak Ridge National Laboratory, used neutron scattering techniques to look for experimental evidence of fractionalisation in crystals of ruthenium chloride

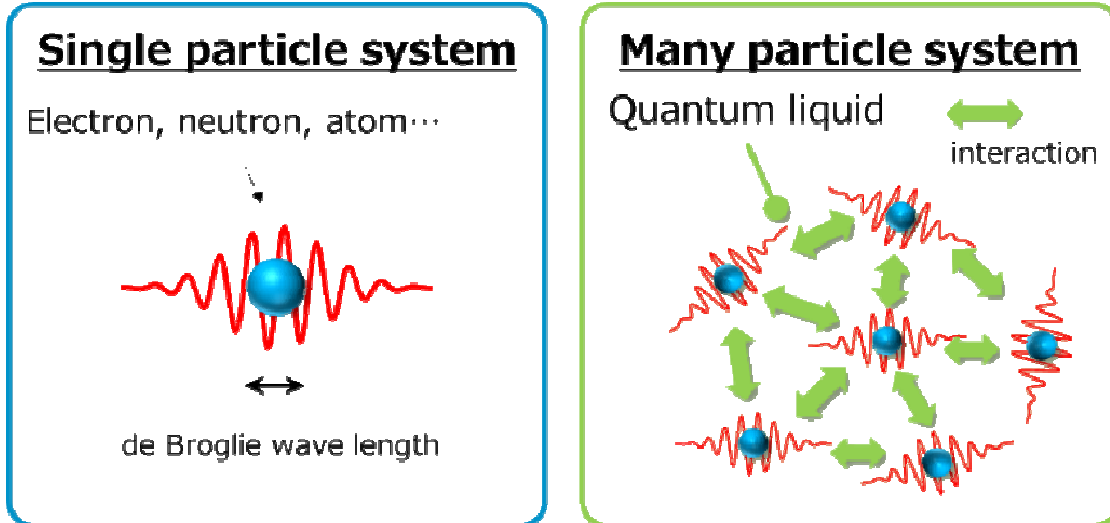
(RuCl<sub>3</sub>). The researchers tested the magnetic properties of the RuCl<sub>3</sub> crystals by illuminating them with neutrons, and observing the pattern of ripples that the neutrons produced on a screen.

A regular magnet would create distinct sharp spots, but it was a mystery what sort of pattern the Majorana fermions in a quantum spin liquid would make. The theoretical prediction of distinct signatures by Knolle and his collaborators in 2014 match well with what experimentalists observed on the screen, providing for the first time direct evidence of a quantum spin liquid and the fractionalisation of electrons in a two dimensional material.

"This is a new addition to a short list of known quantum states of matter," said Knolle.

"It's an important step for our understanding of quantum matter," said Kovrizhin. "It's fun to have another new quantum state that we've never seen before - it presents us with new possibilities to try new things." [12]

### Mysterious behavior of quantum liquid elucidated, a world first



In cooperation with researchers from Osaka City University and the University of Tokyo, researchers at Osaka University, through their precise measurement of current fluctuations in quantum liquids in an artificial atom created by nanotechnology, succeeded in elucidating theoretically-predicted behavior of quantum liquid in a non-equilibrium regime.

Quantum liquids are macroscopic ensembles of interacting particles dense enough for quantum statistics to manifest itself. For fermions, it is known that, around equilibrium, all the quantum liquids can be universally described within a single theory, so called Landau Fermi liquid theory. The central idea is that they can be treated as an ensemble of free "quasi-particles". This conceptual framework has been applied to many physical systems, such as liquid helium 3, normal metals, heavy fermions, neutron stars, and cold gases, where their properties in the linear-response regime have been successfully described by the theory. However, non-equilibrium properties beyond this regime have still to be established and remain a key issue of many-body physics.

Kensuke Kobayashi, Meydi Ferrier, Tomonori Arakawa, Tokuro Hata, Ryo Fujiwara at Osaka University in collaboration with Akira Oguri at Osaka City University and Rui Sakano at the University of Tokyo together with Raphaëlle Delagrangé, Raphaël Weil, Richard Deblock at Laboratoire de Physique des Solides, CNRS, Univ. Paris-Sud, Université Paris Saclay show a precise experimental demonstration of Landau Fermi-liquid theory extended to the non-equilibrium regime in a 0-D system. Combining transport and sensitive current noise measurements, they have identified the  $SU(2)$  and  $SU(4)$  symmetries of quantum liquid in a carbon nanotube tuned in the Kondo regime. They find that, while the electronic transport is well described by the free quasi-particle picture around equilibrium just as the Fermi liquid theory tells us, a two-particle scattering process due to residual interaction shows up in the non-equilibrium regime. The result, in perfect agreement with theory, provides a strong quantitative experimental background for further developments of the many-body physics. Moreover, they discovered a new scaling law for the effective charge, signaling as-yet-unknown universality in the non-equilibrium regime.

This achievement will open up a new way to explore quantum many-body physics through fluctuations, which stands on firm ground even out of equilibrium beyond the conventional Landau Fermi liquid theory. The newly discovered universality would trigger a vast theoretical effort. [11]

## **Physicists find quantum coherence and quantum entanglement are two sides of the same coin**

Quantum coherence and quantum entanglement are two landmark features of quantum physics, and now physicists have demonstrated that the two phenomena are "operationally equivalent"—that is, equivalent for all practical purposes, though still conceptually distinct. This finding allows physicists to apply decades of research on entanglement to the more fundamental but less-well-researched concept of coherence, offering the possibility of advancing a wide range of quantum technologies.

### **Close relatives with the same roots**

Although physicists have known that coherence and entanglement are close relatives, the exact relationship between the two resources has not been clear.

It's well-known that quantum coherence and quantum entanglement are both rooted in the superposition principle—the phenomenon in which a single quantum state simultaneously consists of multiple states—but in different ways. Quantum coherence deals with the idea that all objects have wave-like properties. If an object's wave-like nature is split in two, then the two waves may coherently interfere with each other in such a way as to form a single state that is a superposition of the two states. This concept of superposition is famously represented by Schrödinger's cat, which is both dead and alive at the same time when in its coherent state inside a closed box. Coherence also lies at the heart of quantum computing, in which a qubit is in a superposition of the "0" and "1" states, resulting in a speed-up over various classical algorithms. When such a state experiences decoherence, however, all of its quantumness is typically lost and the advantage vanishes.

The second phenomenon, quantum entanglement, also involves superposition. But in this case, the states in a superposition are the shared states of two entangled particles rather than those of the two split waves of a single particle. The intrigue of entanglement lies in the fact that the two entangled particles are so intimately correlated that a measurement on one particle instantly affects the other particle, even when separated by a large distance. Like coherence, quantum entanglement also plays an essential role in quantum technologies, such as quantum teleportation, quantum cryptography, and super dense coding.

### **Converting one to the other**

In a paper to be published in Physical Review Letters, physicists led by Gerardo Adesso, Associate Professor at the University of Nottingham in the UK, with coauthors from Spain and India, have provided a simple yet powerful answer to the question of how these two resources are related: the scientists show that coherence and entanglement are quantitatively, or operationally, equivalent, based on their behavior arising from their respective resource theories.

The physicists arrived at this result by showing that, in general, any nonzero amount of coherence in a system can be converted into an equal amount of entanglement between that system and another initially incoherent one. This discovery of the conversion between coherence and entanglement has several important implications. For one, it means that quantum coherence can be measured through entanglement. Consequently, all of the comprehensive knowledge that researchers have obtained about entanglement can now be directly applied to coherence, which in general is not nearly as well-researched (outside of the area of quantum optics). For example, the new knowledge has already allowed the physicists to settle an important open question concerning the geometric measure of coherence: since the geometric measure of entanglement is a "full convex monotone," the same can be said of the associated coherence measure. As the scientists explained, this is possible because the new results allowed them to define and quantify one resource in terms of the other.

"The significance of our work lies in the fact that we prove the close relation between entanglement and coherence not only qualitatively, but on a quantitative level," coauthor Alex Streltsov, of ICFO-The Institute of Photonic Sciences in Barcelona, told Phys.org. "More precisely, we show that any quantifier of entanglement gives rise to a quantifier of coherence. This concept allowed us to prove that the geometric measure of coherence is a valid coherence quantifier, thus answering a question left open in several previous works."

While the results show that coherence and entanglement are operationally equivalent, the physicists explain that this doesn't mean that are the exact same thing, as they are still conceptually different ideas.

"Despite having the same roots of origin, namely quantum superposition, coherence and entanglement are conceptually different," said coauthors Uttam Singh, Himadri Dhar, and Manabendra Bera at the Harish-Chandra Research Institute in Allahabad, India. "For example, coherence can be present in single quantum systems, where entanglement is not well-defined. Also, coherence is defined with respect to a given basis, while entanglement is invariant under local basis changes. In all, we believe coherence and entanglement are operationally equivalent but conceptually different."

## Future quantum connections

The operational equivalence of coherence and entanglement will likely have a far-reaching impact on areas ranging from quantum information theory to more nascent fields such as quantum biology and nanoscale thermodynamics. In the future, the physicists plan to investigate whether coherence and entanglement might also be interconverted into a third resource—that of quantum discord, which, like entanglement, is another type of quantum correlation between two systems.

"Our future plans are diverse," Adesso said. "On the theoretical side, we are working to construct a unified framework to interpret, classify and quantify all different forms of quantum resources, including and beyond entanglement and coherence, and highlight the interlinks among them from an operational perspective. This will allow us to navigate the hierarchy of quantumness indicators in composite systems with a common pilot, and to appreciate which particular ingredients are needed in various informational tasks.

"On the practical side, we are investigating experimentally friendly schemes to detect, quantify, and preserve coherence, entanglement and other quantum correlations in noisy environments. More fundamentally, we hope these results will inspire us to devise scalable and efficient methods to convert between different quantum resources for technological applications, and bring us closer to understanding where the boundaries of the quantum world ultimately lie in realistic scenarios." [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 electrodynamic 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 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 1/2 spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with 1/2 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  $\frac{1}{2}$  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 than subatomic matter structures as an electric dipole change. There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.

The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

## Fermions and Bosons

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

## Van Der Waals force

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

## Electromagnetic inertia and mass

### Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

### Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

### The frequency dependence of mass

Since  $E = h\nu$  and  $E = mc^2$ ,  $m = h\nu / c^2$  that is the  $m$  depends only on the  $\nu$  frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the  $m_0$  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 Big 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 ratio  $M_p=1840 M_e$ . 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]

## Dark Matter and Energy

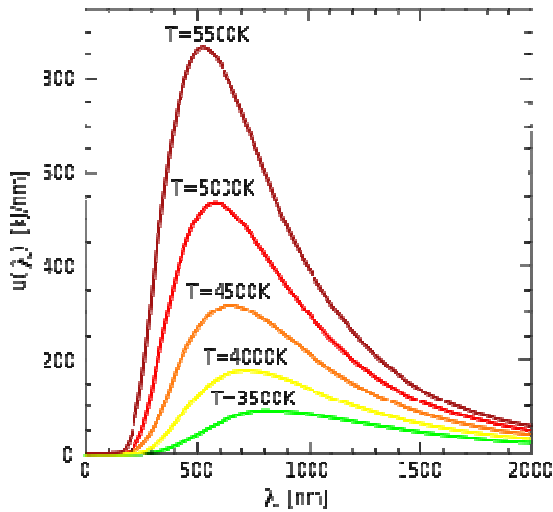
Dark matter is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant 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

The operational equivalence of coherence and entanglement will likely have a far-reaching impact on areas ranging from quantum information theory to more nascent fields such as quantum biology and nanoscale thermodynamics. In the future, the physicists plan to investigate whether coherence and entanglement might also be interconverted into a third resource—that of quantum discord, which, like entanglement, is another type of quantum correlation between two systems. [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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