

# Self-Healing Material Electrically Activated

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*The same researchers who pioneered the use of a quantum mechanical effect to convert heat into electricity have figured out how to make their technique work in a form more suitable to industry. [10]*

*Systems out of thermodynamic equilibrium are very common in nature. In recent years they have attracted constantly growing attention because of their relevance for fundamental physics as well as for modern nanotechnology. [9]*

*A team of physicists at ANU have used a technique known as 'ghost imaging' to create an image of an object from atoms that never interact with it. [8]*

*For centuries, scientists believed that light, like all waves, couldn't be focused down smaller than its wavelength, just under a millionth of a metre. Now, researchers led by the University of Cambridge have created the world's smallest magnifying glass, which focuses light a billion times more tightly, down to the scale of single atoms. [7]*

*A Purdue University physicist has observed a butterfly Rydberg molecule, a weak pairing of two highly excitable atoms that he predicted would exist more than a decade ago. [6]*

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*In the quantum world, physicists study the tiny particles that make up our classical world - neutrons, electrons, photons - either one at a time or in small numbers because the behaviour of the particles is completely different on such a small scale. If you add to the number of particles that are being studied, eventually there will be enough particles that they no longer act quantum mechanically and must be identified as classical, just like our everyday world. But where is the line between the quantum world and the classical world? A group of scientists from Okinawa Institute of Science and Technology Graduate*

*University (OIST) explored this question by showing what was thought to be a quantum phenomenon can be explained classically. [4]*

*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.*

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## Preface

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.

## A wolverine inspired material: Self-healing, transparent, highly stretchable material can be electrically activated

Scientists, including several from the University of California, Riverside, have developed a transparent, self-healing, highly stretchable conductive material that can be electrically activated to power artificial muscles and could be used to improve batteries, electronic devices, and robots.

The findings, which were published today in the journal *Advanced Material*, represent the first time scientists have created an ionic conductor, meaning materials that ions can flow through, that is transparent, mechanically stretchable, and self-healing.

The material has potential applications in a wide range of fields. It could give robots the ability to self-heal after mechanical failure; extend the lifetime of lithium ion batteries used in electronics and electric cars; and improve biosensors used in the medical field and environmental monitoring.

"Creating a material with all these properties has been a puzzle for years," said Chao Wang, an adjunct assistant professor of chemistry who is one of the authors of the paper. "We did that and now are just beginning to explore the applications."

This project brings together the research areas of self-healing materials and ionic conductors.

Inspired by wound healing in nature, self-healing materials repair damage caused by wear and extend the lifetime, and lower the cost, of materials and devices. Wang developed an interest in self-healing materials because of his lifelong love of Wolverine, the comic book character who has the ability to self-heal.

Ionic conductors are a class of materials with key roles in energy storage, solar energy conversion, sensors, and electronic devices.

Another author of the paper, Christoph Keplinger, an assistant professor at the University of Colorado, Boulder, previously demonstrated that stretchable, transparent, ionic conductors can be used to power artificial muscles and to create transparent loudspeakers – devices that feature several of the key properties of the new material (transparency, high stretchability and ionic conductivity) – but none of these devices additionally had the ability to self-heal from mechanical damage.

The key difficulty is the identification of bonds that are stable and reversible under electrochemical conditions. Conventionally, self-healing polymers make use of non-covalent bonds, which creates a problem because those bonds are affected by electrochemical reactions that degrade the performance of the materials.

Wang helped solve that problem by using a mechanism called ion-dipole interactions, which are forces between charged ions and polar molecules that are highly stable under electrochemical conditions. He combined a polar, stretchable polymer with a mobile, high-ionic-strength salt to create the material with the properties the researchers were seeking.

The low-cost, easy to produce soft rubber-like material can stretch 50 times its original length. After being cut, it can completely re-attach, or heal, in 24 hours at room temperature. In fact, after only five minutes of healing the material can be stretched two times its original length.

Timothy Morrissey and Eric Acome, two graduate students working with Keplinger, demonstrated that the material could be used to power a so-called artificial muscle, also called dielectric elastomer actuator. Artificial muscle is a generic term used for materials or devices that can reversibly contract, expand, or rotate due to an external stimulus such as voltage, current, pressure or temperature.

The dielectric elastomer actuator is actually three individual pieces of polymer that are stacked together. The top and bottom layers are the new material developed at UC Riverside, which is able to conduct electricity and is self-healable, and the middle layer is a transparent, non-conductive rubber-like membrane.

The researchers used electrical signals to get the artificial muscle to move. So, just like how a human muscle (such as a bicep) moves when the brain sends a signal to the arm, the artificial muscle also reacts when it receives a signal. Most importantly, the researchers were able to demonstrate that the ability of the new material to self-heal can be used to mimic a preeminent survival feature of nature: wound-healing. After parts of the artificial muscle were cut into two separate pieces, the material healed without relying on external stimuli, and the artificial muscle returned to the same level of performance as before being cut.

The paper is called "A transparent, self-healing, highly stretchable ionic conductor." [11]

## Devices that convert heat into electricity one step closer to reality

The same researchers who pioneered the use of a quantum mechanical effect to convert heat into electricity have figured out how to make their technique work in a form more suitable to industry.

In Nature Communications, engineers from The Ohio State University describe how they used magnetism on a composite of nickel and platinum to amplify the voltage output 10 times or more—not in a thin film, as they had done previously, but in a thicker piece of material that more closely resembles components for future electronic devices.

Many electrical and mechanical devices, such as car engines, produce heat as a byproduct of their normal operation. It's called "waste heat," and its existence is required by the fundamental laws of thermodynamics, explained study co-author Stephen Boona.

But a growing area of research called solid-state thermoelectrics aims to capture that waste heat inside specially designed materials to generate power and increase overall energy efficiency.

"Over half of the energy we use is wasted and enters the atmosphere as heat," said Boona, a postdoctoral researcher at Ohio State. "Solid-state thermoelectrics can help us recover some of that energy. These devices have no moving parts, don't wear out, are robust and require no maintenance. Unfortunately, to date, they are also too expensive and not quite efficient enough to warrant widespread use. We're working to change that."

In 2012, the same Ohio State research group, led by Joseph Heremans, demonstrated that magnetic fields could boost a quantum mechanical effect called the spin Seebeck effect, and in turn boost the voltage output of thin films made from exotic nano-structured materials from a few microvolts to a few millivolts.

In this latest advance, they've increased the output for a composite of two very common metals, nickel with a sprinkling of platinum, from a few nanovolts to tens or hundreds of nanovolts—a smaller voltage, but in a much simpler device that requires no nanofabrication and can be readily scaled up for industry.

Heremans, a professor of mechanical and aerospace engineering and the Ohio Eminent Scholar in Nanotechnology, said that, to some extent, using the same technique in thicker pieces of material required that he and his team rethink the equations that govern thermodynamics and thermoelectricity, which were developed before scientists knew about quantum mechanics. And while quantum mechanics often concerns photons—waves and particles of light—Heremans' research concerns magnons—waves and particles of magnetism.

"Basically, classical thermodynamics covers steam engines that use steam as a working fluid, or jet engines or car engines that use air as a working fluid. Thermoelectrics use electrons as the working fluid. And in this work, we're using quanta of magnetization, or 'magnons,' as a working fluid," Heremans said.

Research in magnon-based thermodynamics was up to now always done in thin films—perhaps only a few atoms thick—and even the best-performing films produce very small voltages.

In the 2012 paper, his team described hitting electrons with magnons to push them through thermoelectric materials. In the current Nature Communications paper, they've shown that the same technique can be used in bulk pieces of composite materials to further improve waste heat recovery.

Instead of applying a thin film of platinum on top of a magnetic material as they might have done before, the researchers distributed a very small amount of platinum nanoparticles randomly throughout a magnetic material—in this case, nickel. The resulting composite produced enhanced voltage output due to the spin Seebeck effect. This means that for a given amount of heat, the composite material generated more electrical power than either material could on its own. Since the entire piece of composite is electrically conducting, other electrical components can draw the voltage from it with increased efficiency compared to a film.

While the composite is not yet part of a real-world device, Heremans is confident the proof-of-principle established by this study will inspire further research that may lead to applications for common waste heat generators, including car and jet engines. The idea is very general, he added, and can be applied to a variety of material combinations, enabling entirely new approaches that don't require expensive metals like platinum or delicate processing procedures like thin-film growth. [10]

## **Quantum friction—beyond the local equilibrium approximation**

Systems out of thermodynamic equilibrium are very common in nature. In recent years they have attracted constantly growing attention because of their relevance for fundamental physics as well as for modern nanotechnology. In a collaborative effort, the Theoretical Optics and Photonics group at the Max-Born-Institut and Humboldt-Universität zu Berlin together with colleagues from the Universität Potsdam, Yale University and the Los Alamos National Laboratory now report on detailed new physical insights of non-equilibrium atom-surface quantum friction.

A particular class of non-equilibrium phenomena is represented by dynamical van der Waals/Casimir forces acting between atoms, molecules and surfaces. These forces, whose origin is deeply rooted in quantum theory, are at the origin of contactless (quantum) friction between two objects that, when separated by a few tens of nanometers, move relative to each other. Unfortunately, the detailed quantitative description of non-equilibrium systems is rather challenging and the most common approaches rely on the assumption that corrections to the associated equilibrium characteristics are relatively small. However, the validity of these procedures and of the corresponding approximations has been scarcely verified, inevitably limiting the reliability of the results.

In stark contrast with widely accepted assumptions that dominate the existing literature, the researchers have shown that the local thermal equilibrium (LTE) approximation, which treats interacting subsystems in a general non-equilibrium system as being locally in equilibrium with their immediate environment, fails dramatically when applied to the study of quantum friction.

Using general quantum statistical arguments and exactly solvable models, the researchers determined that the LTE approximation underestimates the magnitude of the drag force by approximately 80%. Considering that the LTE approximation has been the workhorse for the theoretical description of many non-equilibrium phenomena, ranging from thermal energy transport

to non-equilibrium dispersion forces, these results demonstrate that LTE-based calculations lack rigorous justification and have to be re-examined.

Besides addressing fundamental questions in the highly interdisciplinary field of van der Waals/Casimir forces, these new results will have considerable impact on many other applications of current interest in non-equilibrium physics, such as miniaturized traps for ultra-cold gases (atom chips), nano-electromechanical systems (NEMS) and near-field radiative heat transfer. Altogether, this work provides a quantitative analysis whose conclusions represent a substantial advance in the understanding of non-equilibrium quantum physics. [9]

## **Researchers demonstrate 'ghost imaging' with atoms**

A team of physicists at ANU have used a technique known as 'ghost imaging' to create an image of an object from atoms that never interact with it.

This is the first time that ghost imaging has been achieved using atoms, although it has previously been demonstrated with light, leading to applications being developed for imaging and remote sensing through turbulent environments.

The atom-based result may lead to a new method for quality control of nanoscale manufacturing, including atomic scale 3-D printing.

Lead researcher Associate Professor Andrew Truscott from the ANU Research School of Physics and Engineering (RSPE) said the experiment relied on correlated pairs of atoms. The pairs were separated by around six centimetres and used to generate an image of the ANU logo.

"One atom in each pair was directed towards a mask with the letters 'ANU' cut-out," Associate Professor Truscott said.

"Only atoms that pass through the mask reach a 'bucket' detector placed behind the mask, which records a 'ping' each time an atom hits it. The second atom in the pair records a 'ping' along with the atom's location on a second spatial detector.

"By matching the times of the 'pings' from pairs of atoms we were able to discard all atoms hitting the spatial detector whose partner had not passed through the mask.

"This allowed an image of 'ANU' to be recreated, even though - remarkably - the atoms forming the image on the spatial detector had never interacted with the mask. That's why the image is termed a 'ghost'."

Professor Ken Baldwin, also from the RSPE team, said the research may eventually be used for quality control in manufacturing microchips or nano devices.

"We might one day be able to detect in real time when a problem occurs in the manufacturing of a microchip or a nano device," Professor Baldwin said.

Co-author Dr Sean Hodgman said on a fundamental level, the research could also be a precursor to investigating entanglement between massive particles, which could help the development of quantum computation.

"This research could open up techniques to probe quantum entanglement, otherwise known as Einstein's spooky action at a distance," Dr Hodgman said. [8]

## **World's smallest magnifying glass makes it possible to see chemical bonds between atoms**

For centuries, scientists believed that light, like all waves, couldn't be focused down smaller than its wavelength, just under a millionth of a metre. Now, researchers led by the University of Cambridge have created the world's smallest magnifying glass, which focuses light a billion times more tightly, down to the scale of single atoms.

In collaboration with colleagues from Spain, the team used highly conductive gold nanoparticles to make the world's tiniest optical cavity, so small that only a single molecule can fit within it. The cavity—called a 'pico-cavity' by the researchers—consists of a bump in a gold nanostructure the size of a single atom, and confines light to less than a billionth of a metre. The results, reported in the journal *Science*, open up new ways to study the interaction of light and matter, including the possibility of making the molecules in the cavity undergo new sorts of chemical reactions, which could enable the development of entirely new types of sensors.

According to the researchers, building nanostructures with single atom control was extremely challenging. "We had to cool our samples to  $-260^{\circ}\text{C}$  in order to freeze the scurrying gold atoms," said Felix Benz, lead author of the study. The researchers shone laser light on the sample to build the pico-cavities, allowing them to watch single atom movement in real time.

"Our models suggested that individual atoms sticking out might act as tiny lightning rods, but focusing light instead of electricity," said Professor Javier Aizpurua from the Center for Materials Physics in San Sebastian, who led the theoretical section of this work.

"Even single gold atoms behave just like tiny metallic ball bearings in our experiments, with conducting electrons roaming around, which is very different from their quantum life where electrons are bound to their nucleus," said Professor Jeremy Baumberg of the NanoPhotonics Centre at Cambridge's Cavendish Laboratory, who led the research.

The findings have the potential to open a whole new field of light-catalysed chemical reactions, allowing complex molecules to be built from smaller components. Additionally, there is the possibility of new opto-mechanical data storage devices, allowing information to be written and read by light and stored in the form of molecular vibrations. [7]

## **Weak atomic bond, theorized 14 years ago, observed for first time**

A Purdue University physicist has observed a butterfly Rydberg molecule, a weak pairing of two highly excitable atoms that he predicted would exist more than a decade ago.

Rydberg molecules are formed when an electron is kicked far from an atom's nucleus. Chris Greene, Purdue's Albert Overhauser Distinguished Professor of Physics and Astronomy, along with his co-



authors H. Sadeghpour and E. Hamilton, theorized in 2002 that such a molecule could attract and bind to another atom.

"For all normal atoms, the electrons are always just one or two angstroms away from the nucleus, but in these Rydberg atoms you can get them 100 or 1,000 times farther away," Greene said.

"Following preliminary work in the late 1980s and early 1990s, we saw in 2002 the possibility that this distant Rydberg electron could bind the atom to another atom at a very large distance. This electron is like a sheepdog. Every time it whizzes past another atom, this Rydberg atom adds a little attraction and nudges it toward one spot until it captures and binds the two atoms together."

A collaboration involving Greene and his postdoctoral associate Jesus Perez-Rios at Purdue and researchers at the University of Kaiserslautern in Germany has now proven the existence of the butterfly Rydberg molecule, so named for the shape of its electron cloud. Their findings were published in the journal Nature Communications.

"This new binding mechanism, in which an electron can grab and trap an atom, is really new from the point of view of chemistry. It's a whole new way an atom can be bound by another atom," Greene said.

The researchers cooled Rubidium gas to a temperature of 100 nano-Kelvin, about one ten-millionth of a degree above absolute zero. Using a laser, they were able to push an electron from its nucleus, creating a Rydberg atom, and then watch it.

"Whenever another atom happens to be at about the right distance, you can adjust the laser frequency to capture that group of atoms that are at a very clear internuclear separation that is predicted by our theoretical treatment," Greene said.

They were able to detect the energy of binding between the two atoms based on changes in the frequency of light that the Rydberg molecule absorbed.

Greene said it's satisfying to know that the predictions made so long ago have been proven.

"It's a really clear demonstration that this class of molecules exist," Greene said. "It also validates the whole theoretical approach that we and a few other groups have taken that led to the prediction and study of this new class of molecules.

"These molecules have huge electric dipole moments which allow them to be manipulated by weak electric fields 100 times smaller than those needed to move common diatomic molecules; this could one day be applied to the development of molecular scale electronics or machines."

Greene will continue to study Rydberg atoms, including tests to see if multiple atoms could be bound to a Rydberg molecule. [6]

## **New method to differentiate molecules could yield faster and cheaper medicines**

In a scientific first, a team of researchers from Macquarie University and the University of Vienna have developed a new technique to measure molecular properties – forming the basis for

improvements in scientific instruments like telescopes, and with the potential to speed up the development of pharmaceuticals.

The study, titled "Quantum Optical Rotatory Dispersion" and published in interdisciplinary journal *Science Advances* today, developed a new technique to allow chemists to learn about the position of atoms in a molecule – called quantum optical rotatory dispersion.

This quantum method measures the chirality of molecules, which is essentially how asymmetric the molecules are and is used across fields like biology, biochemistry and physics, and has a practical application in pharmaceuticals among other sectors.

The team found that quantum methods can allow for a more precise analysis of properties of molecules – meaning molecules can be examined even with a low concentration of the molecule or with less light. This new technique enables a more gentle analysis of samples that, for example, may be damaged by light.

"We've found a way to analyse delicate samples by using less light," said lead author Nora Tischler, who carried out the research as part of her PhD, which she completed at Macquarie University between 2012 and 2016.

"We hope to see this proof of concept built upon to eventually see efficiencies in the pharmaceutical sector, to help develop new medicines more productively."

Macquarie's Associate Professor Gabriel Molina-Terriza from the Department of Physics and Astronomy co-authored the study, alongside postdoctoral fellow Xavier Vidal and researchers from the Austrian Academy of Sciences and University of Vienna. The lead author was jointly enrolled at the University of Vienna and Macquarie University as part of a cotutelle PhD program, spurring the international partnership between the two teams.

"We sought out to understand how light couples to matter – which is at the core of many common instruments. Ultimately we hope our findings can be used to find new ways to improve instruments like optical sensors and telescopes," said Associate Professor Molina-Terriza. [5]

## **Bridging the gap between the quantum and classical worlds**

In the quantum world, physicists study the tiny particles that make up our classical world - neutrons, electrons, photons - either one at a time or in small numbers because the behaviour of the particles is completely different on such a small scale. If you add to the number of particles that are being studied, eventually there will be enough particles that they no longer act quantum mechanically and must be identified as classical, just like our everyday world. But where is the line between the quantum world and the classical world? A group of scientists from Okinawa Institute of Science and Technology Graduate University (OIST) explored this question by showing what was thought to be a quantum phenomenon can be explained classically.

They have recently published their results in *Physical Review Letters*.

"We wanted to know about the relationship and interactions between light and matter," Prof. Denis Konstantinov, author and leader of OIST's Quantum Dynamics Unit said. "By light we mean

electromagnetic fields: radio waves, microwaves, or light. They are all described by the same laws in physics. By matter, we mean a collection of tiny particles, like atoms or electrons."

Specifically, the team was interested in strong coupling in light-matter interactions where there are a large number of particles that make up the matter. Strong coupling is when the light and the matter are both affected by the interactions. In most circumstances, the light is not affected when light and matter interact. For example, a boat in the ocean is affected by the waves, but the ocean is not really affected by the presence of the boat. Strong coupling is interesting because both the boat (matter) and waves (light) are strongly affected by the interaction with the other. Generally, this has been thought of as a quantum effect. However, the researchers wanted to explore the boundary between the quantum and classical worlds.

"Everyone agrees that if you have a collection of a large number of quantum particles it is classical and if you have light trapped in a cavity, it is also classical," Konstantinov said. "But then, if we bring them together and strongly couple them, it somehow becomes quantum. This didn't seem quite right to us."

To see whether this type of strong coupling could be explained classically, the researchers took a collection of tens to hundreds of millions of electrons on the surface of liquid helium, which exists at very low temperatures. They then brought the electrons into a cavity containing electromagnetic microwaves. From there, the electrons and the waves could interact and the team observed changes in both the electrons and the electromagnetic waves.

"We saw strong changes in the electromagnetic wave frequency while they were interacting with the electrons and strong changes in the electrons' activity as well," Konstantinov said. "This is a signature of strong coupling."

From there, they successfully created a classical model that described the phenomenon of strong coupling that they were seeing experimentally. This meant that strong coupling with large amounts of particles could be categorized in the classical world instead of the quantum world as previously thought.

"The transition from the quantum world to classical behaviour is not really clear. But in this case we have shown where the quantum ends and the classical begins," Konstantinov said. "However, while this strong coupling itself is classical, it does not mean that nothing is quantum. You can bring this system to a quantum regime by introducing non-linearity like a qubit."

Qubits are units of quantum information that are integral to quantum computing because they exist in a superposition of two states and can hold a much larger amount of information compared to a regular bit used in normal computers. Understanding strong coupling and their relation to qubits could be significant for the development of quantum computing.

"Strong coupling is very important for quantum computing," Konstantinov said. "If you have strong coupling you can exchange quantum information between qubits, light, and particles, which can serve as quantum memory." [4]

## The Bridge

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

## Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.

The same thing happens on the atomic scale giving a  $dp$  impulse difference and a  $dx$  way difference between the different part of the not point like particles.

## Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly:  $ds/dt = at$  (time coordinate), but in the reference frame of the current it is parabolic:  $s = a/2 t^2$  (geometric coordinate).

## Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on  $\Delta x$  position difference and with a  $\Delta p$  momentum difference such a way that they product is about the half Planck reduced constant. For the proton this  $\Delta x$  much less in the nucleon, than in the orbit of the electron in the atom, the  $\Delta p$  is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

## Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on  $\Delta x$  position with  $\Delta p$  impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

## Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that

changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

## The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics 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.

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

### The Higgs boson

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



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

## Higgs mechanism and Quantum Gravity

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

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

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

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

## What is the Spin?

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

## The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor

(compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

## Conclusions

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

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.

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