Bohr's Quantum Theory

Niels Bohr's atomic model was utterly revolutionary when it was presented in 1913. Although it is still taught in schools, it became obsolete decades ago. However, its creator also developed a much wider-ranging and less known quantum theory, the principles of which changed over time. Researchers at the University of Barcelona have now analysed the development in the Danish physicist's thought – a real example of how scientific theories are shaped. [13]

The field of spintronics focuses on spin transport behavior in magnetic metals, and the major findings in this area have important implications for the field of electronics. [12]

Periodic motions of atoms over a length of a billionth of a millionth of a meter (10-15 m) are mapped by ultrashort x-ray pulses. [11]

High-energy electrons synced to ultrafast laser pulse to probe how vibrational states of atoms change in time. [10]

A small team of researchers with affiliations to institutions in Italy, Japan and the U.S. has created a simulation that suggests that it should be possible for a single photon to simultaneously excite two atoms. [9]

Molecules vibrate in many different ways—like tiny musical instruments. [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 meter. 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]

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. [5]

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.

Bohr's quantum theory revised

Niels Bohr's atomic model was utterly revolutionary when it was presented in 1913. Although it is still taught in schools, it became obsolete decades ago. However, its creator also developed a much wider-ranging and less known quantum theory, the principles of which changed over time. Researchers at the University of Barcelona have now analysed the development in the Danish physicist's thought – a real example of how scientific theories are shaped.

Most schools still teach the atomic model, in which electrons orbit around the nucleus like the planets do around the sun. The model was based on Rutherford's first model, the principles of classical mechanics and emerging ideas about 'quantisation' (equations to apply initial quantum hypotheses to classical physical systems) advanced by Max Planck and Albert Einstein.

As Blai Pié i Valls, a physicist at the University of Barcelona, explains to SINC: "Bohr published his model in 1913 and, although it was revolutionary, it was a proposal that did little to explain highly varied experimental results, so between 1918 and 1923 he established a much more wide-ranging, well-informed theory that incorporated his previous model."

Bohr's theory, called quantum theory, proposed that electrons circle the nucleus following the classical laws but subject to limitations, such as the orbits they can occupy and the energy they lose as radiation when they jump from one orbit to another. But it also attempted to explain in a unified way all the quantum phenomena that had been observed to date.

"This theory rested on two fundamental pillars: the adiabatic principle, a method to find possible quantum states within the atom; and the correspondence principle, which links classic electrodynamics with the new quantum theory forged at that time," explains Pié i Valls who, together with Professor Enric Pérez, has published these historical analyses on the topic in the journal 'Annalen der Physik'.

The authors studied the use Bohr gave to the adiabatic hypothesis from when Austrian physicist Paul Ehrenfest set it out in 1911 until his Danish colleague raised it to a 'principle' and developed it to get the most out of it. They also detected the mutual influence between Bohr and German physicist Arnold Sommerfeld, who advanced his own formulation of 'quantification' and had a significant influence on developing the old quantum theory, the backdrop against which all the studies prior to the birth of quantum mechanics in 1925 were set.

"One of the most significant changes we have found is the reversal of the importance of the two fundamental principles," notes Pié i Valls. "In 1918, the central role played by the adiabatic principle almost entirely eclipsed the correspondence principle in Bohr's theory, and we mustn't forget that, but over the years, it faded into the background, while the correspondence theory gained importance and incorporated new, useful applications from calculus. With the establishment of quantum mechanics, the correspondence principle retained its central role, which it has to this day."

The authors bemoan the fact that Bohr's quantum theory is much less widely known than his atomic model, "obsolete since 1925, but which is still explained in schools today due to its considerable educational value and out of pure pragmatism—it is impossible to teach a theory as complex as quantum mechanics at certain levels."

This situation, however, has led to the public wrongly having the idea that the Bohr model is still valid, when the modern vision of the atom is, in fact, governed by the probabilistic laws of quantum mechanics, which force us to imagine the electron as a delocalised "probability cloud" around the nucleus of the atom. [13]

Surprising spin behavior at room temperature

The field of spintronics focuses on spin transport behavior in magnetic metals, and the major findings in this area have important implications for the field of electronics. This is because conventional electronics primarily considers the electron charge, whereas spintronics allows the electron spin to be exploited. One of the most significant advancements in spintronics has been the introduction of spin degrees of freedom to semiconductors, which are essential components of modern electronic and photonic applications. However, most experiments investigating spin manipulation in semiconductors have been performed under high magnetic fields and at cryogenic temperatures.

Recently, Nozomi Nishizawa and Hiro Munekata and colleagues, from the Institute of Innovative Research, Tokyo Institute of Technology, examined the behavior of spin-polarized light-emitting diodes (LEDs) at room temperature and without an external magnetic field. Hence, they achieved the unexpected result of almost purely circularly polarized (CP) electroluminescence (EL).

The LEDs used in the study contained an epitaxial double heterostructure (sandwich-like structure) of AlGaAs/GaAs/AlGaAs, a crystalline AlOx tunnel barrier (for electrical stability during operation), and a polycrystalline Fe in-plane spin injector. During operation, spins of a given type were injected into the device. Spin relaxation then caused these spins to disperse and adopt other orthogonal orientations. Radiative recombination subsequently occurred, which was observed in the form of a linearly polarized emission.

Experiments on the LED chips showed that a higher current density generated an increase in the emission intensity. Nishizawa and coworkers also noted that the difference between the left- and right-handed EL components increased with the current density. Specifically, the intensity of the left-handed minority component decreased with increased current density, whereas that of the right-handed majority component increased linearly. Therefore, when the current density was sufficiently high (~ 100 A/scm), almost pure CP was achieved. Investigating this behavior in more detail, the researchers found that p-type doping in the active layer allowed the CP observation, which arose from spin-dependent nonlinear processes occurring at a sufficiently high current density.

In the future, higher current densities will be applied in order to elucidate the mechanism behind these nonlinear processes and to investigate the possibility of stimulated CP emission in other geometries. Other important avenues of investigation also exist, e.g., potential spin-LED applications in secure optical communications, cancer diagnosis, and optically enhanced nuclei imaging. [12]

Ultrasmall atom motions recorded with ultrashort x-ray pulses

Periodic motions of atoms over a length of a billionth of a millionth of a meter (10-15 m) are mapped by ultrashort x-ray pulses. In a novel type of experiment, regularly arranged atoms in a crystal are set into vibration by a laser pulse and a sequence of snapshots is generated via changes of x-ray absorption.

A crystal represents a regular and periodic spatial arrangement of atoms or ions which is held together by forces between their electrons. The atomic nuclei in this array can undergo different types of oscillations around their equilibrium positions, the so-called lattice vibrations or phonons. The spatial elongation of nuclei in a vibration is much smaller than the distance between atoms, the latter being determined by the distribution of electrons. Nevertheless, the vibrational motions act back on the electrons, modulate their spatial distribution and change the electric and optical properties of the crystal on a time scale which is shorter than 1 ps (10-12 s). To understand these effects and exploit them for novel, e.g., acoustooptical, devices, one needs to image the delicate interplay of nuclear and electronic motions on a time scale much shorter than 1 ps.

In a recent Rapid Communication in Physical Review B, researchers from the Max Born Institute in Berlin (Germany), the Swiss Federal Laboratories for Materials Science and Technology in Dübendorf (Switzerland), and the National Institute of Standards and Technology, Gaithersburg (USA) apply a novel method of optical pump - soft x-ray probe spectroscopy for generating coherent atomic vibrations in small LiBH4 crystals, and reading them out via changes of x-ray absorption. In their experiments, an optical pump pulse centered at 800 nm excites via impulsive Raman scattering a coherent optical phonon with Ag symmetry [movie]. The atomic motions change the distances between the Li+ und (BH4)- ions. The change in distance modulates the electron distribution in the crystal and, thus, the x-ray absorption spectrum of the Li+ ions. In this way, the atomic motions a mapped into a modulation of soft x-ray absorption on the so-called Li K-edge around 60 eV. Ultrashort x-ray pulses measure the x-ray absorption change at different times. From this series of snapshots the atomic motions are reconstructed.

What happens in the unit cell of crystalline LiBH4 after impulsive Raman excitation with a femtosecond laser pulse? Upper panel: measured transient absorption change ? A(t) (symbols) as we vary the time delay between infrared pump pulses and soft …more

This novel experimental scheme is highly sensitive and allows for the first time to kick off and detect extremely small amplitudes of atomic vibrations. In our case, the Li+ ions move over a distance of only 3 femtometers = 3 x 10-15 m which is comparable to the diameter of the Li+ nucleus and 100000 times smaller than a distance between the ions in the crystal. The experimental observations are in excellent agreement with in-depth theoretical calculations of transient x-ray absorption. This new type of optical pump-soft x-ray probe spectroscopy on a femtosecond time scale holds strong potential for measuring and understanding the interplay of nuclear and electronic motions in liquid and solid matter, a major prerequisite for theoretical simulations and applications in technology. [11]

High-energy electrons synced to ultrafast laser pulse to probe how vibrational states of atoms change in time

A new ultrafast technique, using high-energy electrons coupled to a laser pump, revealed insights into atomic vibrational dynamics in a laser-heated gold thin film. This technique directly measured the phonon spectrum (quantized packets of energy related to atomic lattice vibrations) and explored the energy transfer from the laser excited electrons to atomic vibrations of the atomic lattice. This work demonstrates that specialized ultra-fast electron diffraction instruments can add to the suite of time-resolved laser pump/probe techniques capable of exploring excitations in materials.

Ultrafast excitation and energy transfer at the atomic scale is important in phase transitions, chemical reactions, and macroscopic energy flow. Relevant vibrational time frames occur in femtoseconds (move the decimal point for 1.0 second 15 times to the left). This research established the usefulness of this technique to resolve changing vibrational states, the understanding of which could advance a range of applications from superconductivity to laser-induced phase transitions.

The interactions of electrons and the atoms they reside in are important for a range of phenomena, from fundamental electron and spin transport, to laser-induced phase transitions. Most experimental techniques are limited in their ability to investigate atomic vibrations (phonons) because, like a thermometer, they average over all of the vibrational states in the material. Now research led by the SLAC National Accelerator Laboratory has directly measured the full frequency range and time dependent behavior of phonons in a laser-heated gold thin film. In the experimental setup, high-energy electrons were emitted from an electrode by an ultrafast laser pulse. Both pulses, electrons and light, continued to the sample. The laser pulse arrived first and excited the resident electrons in the gold material, which was then probed by scattering the subsequent electron pulse into a detector. The pump/probe technique, involving the newly developed ultrafast electron diffraction source, measured the positions of the atoms as a function of the controlled and variable time between pump and probe.

Analysis of the atomic vibrations helps determine how light energy, first absorbed by the electrons around atoms, eventually is transferred to the motion of the atoms themselves. The analysis showed varying coupling times between the electron and phonon excitations. The results confirmed that energy transfers faster to higher frequency vibrations than to phonons at lower frequencies. This new tool can be used to understand energy transport at its shortest length and time scales and thus advance the understanding of materials phenomena where thermal energy is critically important, such as in superconducting and thermoelectric devices. [10]

Simulations show a single photon can simultaneously excite two atoms

A small team of researchers with affiliations to institutions in Italy, Japan and the U.S. has created a simulation that suggests that it should be possible for a single photon to simultaneously excite two atoms. In their paper published in the open access journal Physical Review Letters, the team describes the process leading to their simulation, what it showed and why they believe their findings have applications in quantum computers.

Scientists have known for several years that it is possible to have a single atom absorb two photons, causing it to move to a higher energy state. The process has actually been observed many times and is now used in microscopy and spectroscopy—its reverse, extracting the two photons from a single atom, has also been used as a means for producing entangled photons. In this new effort, the researchers wanted to know if the same would hold true for causing a single photon to be absorbed by two different atoms—theory has already suggested it should be possible.

To find out, the team created a simulation in which two atoms were held in place by mirrors inside of a chamber—creating a virtual optical cavity. They reasoned that the size of the cavity should be based on the frequency and wavelength of the photon that would be introduced (i.e. it should be double that of the photon). They then introduced the photon and found that in such a circumstance, both atoms were able to absorb the photon—each grabbing half of its energy—and moving into a higher energy state. And because the process could be reversed—the two atoms together producing a single photon, the team believes it might be possible to use the phenomenon in a quantum system—one of the atoms would theoretically serve as a qubit, carrying information. To give up its information, the qubit would move the information to the cavity where the second atom could be used to control transmission.

The researchers found that the simulation worked for three atoms and one photon, as well—the energy from the photon was equally divided between the atoms. [9]

Synopsis: Detecting a Molecular Duet

Molecules vibrate in many different ways—like tiny musical instruments. Nearby molecules can even vibrate in “harmony” with each other, as observed in large molecular systems. For the first time, researchers have detected such vibrational coupling between two individual molecules. The experimental technique—based on a scanning tunneling microscope (STM)—may offer a new way to study the chemical components of complex molecules.

Molecular vibrations can be studied with so-called inelastic electron tunneling spectroscopy (IETS). This technique is based on the fact that a molecule adsorbed on the tip of an STM probe (or on the surface beneath the probe) will affect the tunneling rate of electrons between probe and surface. In particular, one can identify peaks in the tunneling current spectrum as the voltage is varied. These peaks correspond to vibrational modes of the adsorbed molecule.

Wilson Ho at the University of California, Irvine, and colleagues performed IETS experiments in which carbon monoxide (CO) molecules were allowed to adsorb on both tip and surface. Working at subkelvin temperatures, the team took tunneling spectra at various tip-sample distances. The molecules repel each other at short-range distances, and this interaction can couple their vibrations. The team detected this coupling by identifying a unique peak in the tunneling spectra. They verified this identification with density-functional calculations. The observed peak shifted in frequency as the tip moved closer to the surface. Ho’s team ascribed this shift to a tilting of the CO molecules, which altered their respective alignment and the intermolecular separation. Other molecules, like OH and SH, should have unique vibrational couplings to CO, implying that one could use a CO-functionalized tip as a sensitive chemical probe.

This research is published in Physical Review Letters. [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°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 Disperson" 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 chilarity of molecules, which is essentially how asymmetric the molecules are and is used across fields like biology, biomechemistry 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 it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.

The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.

We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.

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

Fermions and Bosons

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

Van Der Waals force

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

Electromagnetic inertia and mass

Electromagnetic Induction

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

Relativistic change of mass

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

The frequency dependence of mass

Since $E = h\nu$ and $E = mc^2$, $m = h\nu / c^2$ that is the m depends only on the ν frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

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

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

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

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

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

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

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

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

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

The Higgs boson

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

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

Higgs mechanism and Quantum Gravity

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

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

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

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

What is the Spin?

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

The Graviton

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

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 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. 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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