Exotic States of Matter

The 2016 Nobel Prize in physics has been awarded to David Thouless, Duncan Haldane and Michael Kosterlitz, three theoretical physicists whose research used the unexpected mathematical lens of topology to investigate phases of matter and the transitions between them. [14]

A team of researchers with members from several institutions in China has developed a new means for studying topological matter in cold-atom systems that involves using a single laser source. [13]

In the pursuit of material platforms for the next generation of electronics, scientists are studying new compounds such as topological insulators (TIs), which support protected electron states on the surfaces of crystals that silicon-based technologies cannot. Dramatic new physical phenomena are being realized by combining this field of TIs with the subfield of spin-based electronics known as spintronics. [12]

Scientists have achieved the ultimate speed limit of the control of spins in a solid state magnetic material. The rise of the digital information era posed a daunting challenge to develop ever faster and smaller devices for data storage and processing. An approach which relies on the magnetic moment of electrons (i.e. the spin) rather than the charge, has recently turned into major research fields, called spintronics and magnonics. [11]

A team of researchers with members from Germany, the U.S. and Russia has found a way to measure the time it takes for an electron in an atom to respond to a pulse of light. [10]

As an elementary particle, the electron cannot be broken down into smaller particles, at least as far as is currently known. However, in a phenomenon called electron fractionalization, in certain materials an electron can be broken down into smaller "charge pulses," each of which carries a fraction of the electron's charge. Although electron fractionalization has many interesting implications, its origins are not well understood. [9]

New ideas for interactions and particles: This paper examines the possibility to origin the Spontaneously Broken Symmetries from the Planck Distribution Law. This way we get a Unification of the Strong, Electromagnetic, and Weak Interactions from the interference occurrences of oscillators. Understanding that the relativistic mass change is the result of the magnetic induction we arrive to the conclusion that the Gravitational Force is also based on the electromagnetic forces, getting a Unified Relativistic Quantum Theory of all 4 Interactions.

Author: George Rajna

Physicists explore exotic states of matter inspired by Nobel-winning research

The 2016 Nobel Prize in physics has been awarded to David Thouless, Duncan Haldane and Michael Kosterlitz, three theoretical physicists whose research used the unexpected mathematical lens of topology to investigate phases of matter and the transitions between them.

Topology is a branch of mathematics that deals with understanding shapes of objects; it's interested in "invariants" that don't change when a shape is deformed, like the number of holes an object has. Physics is the study of matter and its properties. The Nobel Prize winners were the first to make the connection between these two worlds.

Everyone is used to the idea that a material can take various familiar forms such as a solid, liquid or gas. But the Nobel Prize recognizes other surprising phases of matter – called topological phases – that the winners proposed theoretically and experimentalists have since explored.

Topology is opening up new platforms for observing and understanding these new states of matter in many branches of physics. I work with theoretical aspects of cold atomic gases, a field which has only developed in the years since Thouless, Haldane and Kosterlitz did their groundbreaking theoretical work. Using lasers and atoms to emulate complex materials, cold atom researchers have begun to realize some of the laureates' predictions – with the promise of much more to come.

Atoms start to behave not as individual particles but as waves in the world of quantum physics.

Cold atoms get us to quantum states of matter

All matter is made up of building blocks, such as atoms. When many atoms come together in a material, they start to interact. As the temperature changes, the state of matter starts to change. For instance, water is a liquid until a fixed temperature, when it turns into vapor (373 degrees Kelvin; 212 degrees Fahrenheit; 100 degrees Celsius); and if you cool, solid ice forms at a fixed temperature (273K; 32℉; 0℃). The laws of physics give us a theoretical limit to how low the temperature can get. This lowest possible temperature is called absolute zero (0K) (and equals -460℉ or -273℃).

Classical physics governs our everyday world. Classical physics tells us that if we cool atoms to really low temperatures, they stop their normally constant vibrating and come to a standstill.

But really, as we cool atoms down to temperatures approaching close to 0K, we leave the regime of classical physics – quantum mechanics begins to govern what we see.

In the quantum mechanical world, if an object's position becomes sharply defined then its momentum becomes highly uncertain, and vice versa. Thus, if we cool atoms down, the momentum of each atom decreases, and the quantum uncertainty of its position grows. Instead of being able to pinpoint where each atom is, we can now only see a blurry space somewhere within which the atom must be. At some point, the neighboring uncertain positions of nearby atoms start overlapping and the atoms lose their individual identities. Surprisingly, the distinct atoms become a single entity, and behave as one coherent unit – a discovery that won a previous Nobel.

This new, amazing way atoms organize themselves at very low temperatures results in new properties of matter; it's no longer a classical solid in which the atoms occupy periodic well-defined positions, like eggs in a carton.

Instead, the material is now in a new quantum state of matter in which each atom has become a wave with its position no longer identifiable. And yet the atoms are not moving around chaotically. Instead, they are highly coherent, with a new kind of quantum order. Just like laser beams, the coherent matter waves of superfluids, superconductors and magnets can produce interference patterns.

Physicists have known about quantum order in superfluids and magnets in three dimensions since the middle of the last century. We understand that the order is lost at a critical temperature due to thermal fluctuations. But in two dimensions the situation is different. Early theoretical work showed that thermal fluctuations would destroy the quantum order even at very low temperatures.

What Thouless, Haldane and Kosterlitz addressed were two important questions: What is the nature of the quantum ordered state of superfluids, superconductors and magnets in low dimensions? What is the nature of the phase transition from the ordered to the disordered state in two dimensions?

Thinking about defects

Kosterlitz and Thouless's innovation was to show that topological defects – vortex and anti-vortex whirls and swirls – are crucial to understand the magnetic and superfluid states of matter in two dimensions. These defects are not just local perturbations in the quantum order; they produce a winding or circulation as one goes around it. The vorticity, which measures how many times one winds around, is measured in integer units of the circulation.

Kosterlitz and Thouless showed that at low temperatures, a vortex is bound up with an anti-vortex so the order survives. As the temperature increases, these defects unbind and grow in number and that drives a transition from an ordered to a disordered state.

It's been possible to visualize the vortices in cold atomic gases that Kosterlitz and Thouless originally proposed, bringing to life the topological defects they theoretically proposed. In my own research, we've been able to extend these ideas to quantum phase transitions driven by increasing interactions between the atoms rather than by temperature fluctuations.

Figuring out step-wise changes in materials

The second part of the Nobel Prize went to Thouless and Haldane for discovering new topological states of matter and for showing how to describe them in terms of topological invariants.

Physicists knew about the existence of a phenomenon called the quantum Hall effect, first observed in two dimensional electrons in semiconductors. The Hall conductance, which is the ratio of the transverse voltage and the current, was observed to change in very precise integer steps as the magnetic field was increased.

This was puzzling because real materials are disordered and messy. How could something so precise be seen in experiments?

It turns out that the current flows only in narrow channels at the edges and not within the bulk of the material. The number of channels is controlled by the magnetic field. Every time an additional channel or lane gets added to the highway, the conductance increase by a very precise integer step, with a precision of one part in billion.

Thouless' insight was to show that the flow of electrons at the boundaries has a topological character: the flow is not perturbed by defects – the current just bends around them and continues with its onward flow. This is similar to strong water flow in a river that bends around boulders.

Thouless figured out that here was a new kind of order, represented by a topological index that counts the number of edge states at the boundary. That's just like how the number of holes (zero in a sphere, one in a doughnut, two in glasses, three in a pretzel) define the topology of a shape and the robustness of the shape so long as it is deformed smoothly and the number of holes remains unchanged.

Global, not local, properties

Interacting topological states are even more remarkable and truly bizarre in that they harbor fractionalized excitations. We're used to thinking of an electron, for instance, with its charge of e as being indivisible. But, in the presence of strong interactions, as in the fractional quantum Hall experiments, the electron indeed fractionalizes into three pieces each carrying a third of a charge!

Haldane discovered a whole new paradigm: in a chain of spins with one unit of magnetic moment, the edge spins are fractionalized into units of one-half.

Remarkably, the global topological properties of the chain completely determine the unusual behavior at the edges. Haldane's remarkable predictions have been verified by experiments on solid state materials containing one-dimensional chains of magnetic ions.

Topological states are new additions to the list of phases of matter, such as, solid, liquid, gas, and even superfluids, superconductors and magnets. The laureates' ideas have opened the floodgates for prizeworthy predictions and observations of topological insulators and topological superconductors. The cold atomic gases present opportunities beyond what can be achieved in materials because of the greater variety of atomic spin states and highly tunable interactions. Beyond the rewards of untangling fascinating aspects of our physical world, this research opens the possibility of using topologically protected states for quantum computing. [14]

Researchers demonstrate a single laser source scheme for studying topological matter in cold-atom systems

A team of researchers with members from several institutions in China has developed a new means for studying topological matter in cold-atom systems that involves using a single laser source. In their paper published in the journal Science, the team describes how the scheme works and outlines possible uses for it.

Monika Aidelsburger with UPMC Sorbonne University offers an overview of the work done by the team in a Perspective piece in the same journal issue and offers some insight into some of the possible directions such research is going.

Research regarding topological matter in cold-atom systems has contributed insights into such systems due to the degree of controllability it offers in simulating condensed matter models—interesting topological phenomena have been observed recently in condensed-matter systems. But at the same time, many have found it rough going due to the tricky nature of dealing with the spin-orbit coupling that is involved. In this new effort, the researchers have come up with an approach that is easier to carry out, and as a bonus, it can be tuned between dimensions of the spin orbit.

Conventional methods have relied on having the role of spin carried out by certain states of an atom, while the coupling has been caused to come about using the light from a laser—most have resorted to actually using two laser beams to achieve hyperfine levels through a Raman transition. To make the process easier, the researchers used a single laser beam, which they split into two parts, allowing for the creation of an optical lattice that was spin-independent, and a Raman beam that was frequency shifted—allowing for a double Raman transition in two dimensions to cause spinflips. This setup makes the work less difficult and offers another advantage—the dimensionality is tunable between one and two dimensions.

The researchers note that while they used bosonic atoms, they believe the scheme would work equally well with fermions, and suggest that because their two-dimensional spin-orbit coupling system is more topological stable, it could offer new research opportunities for those studying unusual quantum phases such as topological superfluids. [13]

Mixing topology and spin

In the pursuit of material platforms for the next generation of electronics, scientists are studying new compounds such as topological insulators (TIs), which support protected electron states on the surfaces of crystals that silicon-based technologies cannot. Dramatic new physical phenomena are being realized by combining this field of TIs with the subfield of spin-based electronics known as spintronics. The success within spintronics of realizing important magnetic technologies such as the spin valve have increased the expectations that new results in TIs might have near-term applications. However, combining these two research threads has relied on "shoehorning" magnetism by forcing magnetic atoms to partially occupy elemental positions in TIs or by applying a conventional magnetic field. Realizing an integrated material that is both intrinsically magnetic and has a topological character has proven more challenging.

Integrating correlation

Recently a team of researchers based in the group of Joseph G. Checkelsky, assistant professor of physics at MIT, and collaborators at the NIST Center for Neutron Research (NCNR), Carnegie Mellon University, and the Beijing Institute of Technology have experimentally demonstrated a "hybrid material" solution to this problem.

They studied a compound of three elements, gadolinium, platinum and bismuth, known together as a ternary compound. In their compound, gadolinium supplies the magnetic order while the platinum-bismuth components support a topological electronic structure. These two components acting in concert make a correlated material that is more than the sum of its parts, showing quantum mechanical corrections to electrical properties at an unprecedented scale. Their results were reported July 18 in Nature Physics.

Proving this delicate interplay between the constituent elements of this compound required studying it from different perspectives. With experimental efforts led by research scientist Takehito Suzuki, the MIT group (including physics graduate student Aravind Devarakonda and physics undergraduate Yu-Ting Liu) synthesized single crystals and studied their electronic and magnetic properties. The team found these crystals at the same time were exotic magnets and exhibited signatures of electronic topology. The latter was observed through the so-called Berry phase corrections to electronic behavior, where they saw the largest such response reported to date in this type of magnet, which is known as an antiferromagnet.

The Berry phase reflects the quantum mechanical nature of the charge-carrying electrons in metals and is influenced by magnetic order. They identified an antiferromagnetic transition temperature of 9.2 kelvins (-443 degrees Fahrenheit). At or below this temperature, magnetic moments of the gadolinium atoms align in an alternating pattern of spin up and spin down. Interestingly, for temperatures significantly higher than this they could observe remnants of this magnetic order in both magnetic and electronic properties, a possible hallmark of the underlying frustrated geometry of the crystal lattice.

Viewed from many angles

While these experiments were enticing, the team wanted to be sure that what they were observing originated from the topological properties that would connect this material to potentially ground-breaking types of future electronic devices. Experimentally, this involved work at national facilities including the NCNR, where Suzuki worked with Robin Chisnell PhD '14 and NIST Fellow Jeffrey W. Lynn. Using a triple axis spectrometer (BT-7), they studied the scattering of neutrons from carefully aligned single crystals in the low temperature antiferromagnetic phase including in different magnetic field conditions. These experiments provided the ability to map the behavior of the magnetic gadolinium spins to precisely know their orientation and response to temperature and magnetic field. In order to do these experiments, naturally occurring gadolinium could not be used due to its overwhelming neutron scattering cross-section, and the researchers used instead a costly isotope known as gadolinium -160.

In general, growing single crystals of these compounds is challenging because of their high melting temperature; the growth process known as a "flux method" requires high-temperature centrifuging to remove the crystals from a bath of liquid bismuth. "It's a bit like growing rock candy sugar crystals, except that we use liquid bismuth instead of water," says Checkelsky. The process is well-known to solid state chemists, but can have a high failure rate. The team was able to obtain enough of the isotope for just two growth runs, both of which turned out to be successful. The subsequent experiments at NCNR were able to provide critical information about the gadolinium moments that shaped the team's understanding of their results.

The team also made use of the National High Magnetic Field Laboratory (NHMFL) based in Tallahassee, Florida. There, the MIT team brought the crystals to measure their response to extreme magnetic conditions involving magnetic fields in excess of 30 T (among the largest DC fields available in the world). The extreme conditions available at the NHMFL also allowed the group to broadly map the electronic and magnetic properties of the crystals to complete the picture of the magnetic order. In particular, they were able to observe a previously unreported phase transition for the gadolinium spins near 25 T that appeared to finally "break" the antiferromagnetic state.

The final aspect of the collaborative effort was with professors Di Xiao of Carnegie Mellon University and Wanxiang Feng of Beijing Institute of Technology, who provided first principles electronic structure calculations based on the experimental data taken at MIT, NCNR, and the NHMFL to determine the underlying electronic character of this new materials system.

"The authors combine high-quality crystal growth, transport measurements, neutron spectroscopy, and theoretical calculations to establish the magnetic ordering and its profound effect on electrical properties in a topological material," says Liang Fu, assistant professor of physics at MIT, who was not involved in this research.

"This seminal work reveals surprising quantum phenomena arising from the interplay between electron topology and correlation. This type of correlated topological phenomena is long sought after, but has been difficult to find in real materials. By identifying the right material, Joe Checkelsky's group and collaborators have found a new, promising platform for fundamental research and potential spintronics applications."

New "hybrid" approach

Checkelsky notes that the experiments reported in Nature Physics provide proof that such a "hybrid approach" to designing new electronic platforms can pay dividends despite the challenge it presents directly to theoretical predictions. "The approach to realize TIs in which the correlated behavior of the underlying electrons plays an important role has stood as a challenge to the TI community. Part of this is due to the increased complexity of correlated electronic systems that increases the difficulty for theoretical predictions to guide experimental work," he says. The results have a wide variety of potential implications, ranging from new approaches to exotic antiferromagnetic materials to new topological phases known as Weyl semimetals. The present experiment demonstrates that forging ahead with experimental work can be successful in then feeding back into theory to make significant progress at the crossroads of complex materials and topological phases. [12]

Femtosecond Laser pulses push Spintronics and Magnonics to the limit

Scientists have achieved the ultimate speed limit of the control of spins in a solid state magnetic material. The rise of the digital information era posed a daunting challenge to develop ever faster and smaller devices for data storage and processing. An approach which relies on the magnetic moment of electrons (i.e. the spin) rather than the charge, has recently turned into major research fields, called spintronics and magnonics.

The researchers were able to induce spin oscillations of the intrinsically highest frequency by using femtosecond laser pulses (1 fs = 10-15 sec). Furthermore, they demonstrated a complete and arbitrary manipulation of the phase and the amplitude of these magnetic oscillations – also called magnons. The length-scale of these magnons is on the order of 1 nanometre.

These results pave the way to the unprecedented frequency range of 20 THz for magnetic recording devices, which can be employed also at the nanometer scale.

The practical implementation of other schemes of magnetic control, based on the use of electric currents, is hampered by a significant heating which requires cooling systems. It is thus important to underline that the concept in the current publication does not involve any heating. This makes the study appealing from the point of view of future applications. However, the possibility to monitor the evolution of a magnet on such short time- and length- scales simultaneously is a major breakthrough also in terms of fundamental science. A new regime, defined by Dr. Bossini as femto-nanomagnonics, has been disclosed. [11]

Superfast light pulses able to measure response time of electrons to light

A team of researchers with members from Germany, the U.S. and Russia has found a way to measure the time it takes for an electron in an atom to respond to a pulse of light. In their paper published in the journal Nature, the team describes their use of a light field synthesizer to create pulses of light so fast that they were able to reveal the time it took for electrons in an atom to respond when struck. Kyung Taec Kim with the Gwangju Institute of Science offers a News & Views piece on the work done by the team in the same journal issue, outlining their work and noting one issue that still needs to be addressed with such work.

As scientists have begun preparing for the day when photons will replace electrons in high speed computers, work is being done to better understand the link between the two. One important aspect of this is learning what happens when photons strike electrons that remain in their atom (rather than being knocked out of them), specifically, how long does it take them to respond.

To find this answer, the researchers used what has come to be known as a light-field synthesizer—it is a device that is able to produce pulses of light that are just half of a single wavelength long—

something many had thought was impossible not too long ago. The pulses are of such short duration that they only last for the time it takes to travel that half wavelength, which in this case, was approximately 380 attoseconds.

The light-field synthesizer works by combining several pulses of light brought together but slightly out of phase, allowing for canceling and ultimately, a single very short pulse. In their experiments, the researchers fired their super-short pulses at krypton atoms held inside of a vacuum. In so doing, they found that it took the electrons 115 attoseconds to respond—the first such measurement of the response time of an electron to a visible light pulse.

The team plans to continue their work by looking at how electrons behave in other materials, and as Kim notes, finding a way to characterize both the amplitude and phase of radiation from atoms driven by a light field. [10]

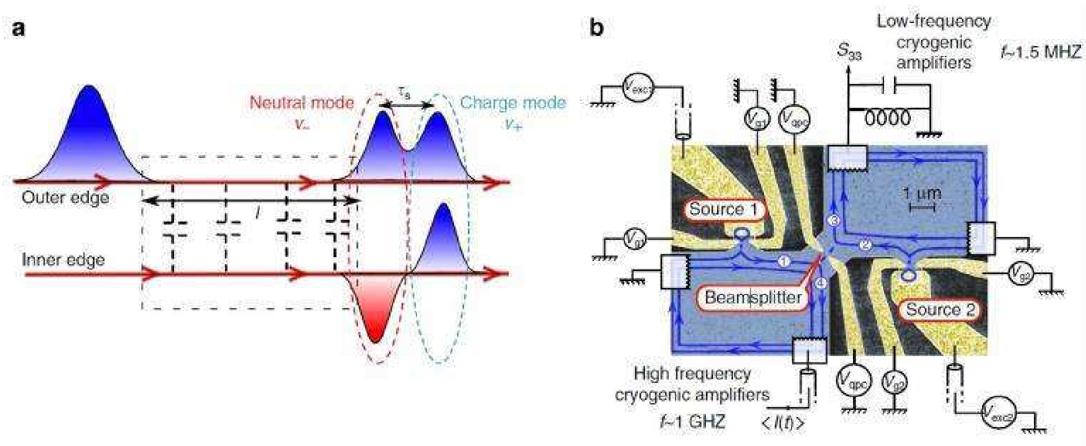
When an electron splits in two

Now in a new paper published in Nature Communications, a team of physicists led by Gwendal Fève at the Ecole Normale Supérieure in Paris and the Laboratory for Photonics and Nanostructures in Marcoussis have applied an experiment typically used to study photons to investigate the underlying mechanisms of electron fractionalization. The method allows the researchers to observe single-electron fractionalization on the picosecond scale.

"We have been able to visualize the splitting of an electronic wavepacket into two fractionalized packets carrying half of the original electron charge," Fève told Phys.org. "Electron fractionalization has been studied in previous works, mainly during roughly the last five years. Our work is the first to combine single-electron resolution—which allows us to address the fractionalization process at the elementary scale—with time resolution to directly visualize the fractionalization process."

The technique that the researchers used is called the Hong-Ou-Mandel experiment, which can be used to measure the degree of resemblance between two photons, or in this case electron charge pulses, in an interferometer. This experiment also requires a single-electron emitter, which some of the same researchers, along with many others, have recently been developing.

The researchers first analyzed the propagation of a single electron in the interferometer's outer one-dimensional wire, and then when that electron fractionalized, they could observe the interaction between its two charge pulses in the inner one-dimensional wire. As the researchers explain, when the original electron travels along the outer wire, Coulomb interactions (interactions between charged particles) between excitations in the outer and inner wires produce two types of excitation pairs: two pulses of the same sign (carrying a net charge) and two pulses of opposite signs (which together are neutral). The two different excitation pairs travel at different velocities, again due to Coulomb interactions, which causes the original electron to split into two distinct charge pulses.



(a) An electron on the outer channel fractionalizes into two pulses. (b) A modified scanning electron microscope picture of the sample. Credit: Freulon, et al. ©2015 Nature

The experiment reveals that, when a single electron fractionalizes into two pulses, the final state cannot be described as a single-particle state, but rather as a collective state composed of several excitations. For this reason, the fractionalization process destroys the original electron particle. Electron destruction can be measured by the decoherence of the electron's wave packet.

Gaining a better understanding of electron fractionalization could have a variety of implications for research in condensed matter physics, such as controlling single-electron currents in one-dimensional wires.

"There has been, during the past years, strong efforts to control and manipulate the propagation of electrons in electronic conductors," Fève said. "It bears many analogies with the manipulations of the quantum states of photons performed in optics. For such control, one-dimensional conductors are useful, as they offer the possibility to guide the electrons along a one-dimensional trajectory. However, Coulomb interactions between electrons are also very strong in one-dimensional wires, so strong that electrons are destroyed: they fractionalize. Understanding fractionalization is understanding the destruction mechanism of an elementary electron in a one-dimensional wire. Such understanding is very important if one wants to control electronic currents at the elementary scale of a single electron."

In the future, the researchers plan to perform further experiments with the Hong-Ou-Mandel interferometer in order to better understand why fractionalization leads to electron destruction, and possibly how to suppress fractionalization.

"The Hong-Ou-Mandel interferometer can be used to picture the temporal extension (or shape) of the electronic wavepackets, which is what we used to visualize the fractionalization process," Fève said. "It can also be used to capture the phase relationship (or phase coherence) between two components of the electronic wavepacket.

"This combined information fully defines the single-electron state, offering the possibility to visualize the wavefunction of single electrons propagating in a one-dimensional conductor. This would first provide a complete understanding of the fractionalization mechanism and in particular how it leads to the decoherence of single-electron states. It would also offer the possibility to test if single electrons can be protected from this decoherence induced by Coulomb interaction. Can we suppress (or reduce) the fractionalization process by reducing the strength of the Coulomb interaction? We would then be able to engineer and visualize pure single-electron states, preserved from Coulomb interaction.

"The next natural step is then to address few-particle states and electron entanglement in quantum conductors. Again, the question of the destruction of such states by Coulomb interaction effects will be a crucial one." [9]

The Electromagnetic Interaction

This paper explains the magnetic effect of the electric current from the observed effects of the accelerating electrons, causing naturally the experienced changes of the electric field potential along the electric wire. 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. [2]

Asymmetry in the interference occurrences of oscillators

The asymmetrical configurations are stable objects of the real physical world, because they cannot annihilate. One of the most obvious asymmetry is the proton – electron mass rate $M_p = 1840\ M_e$ while they have equal charge. We explain this fact by the strong interaction of the proton, but how remember it his strong interaction ability for example in the H – atom where are only electromagnetic interactions among proton and electron.

This gives us the idea to origin the mass of proton from the electromagnetic interactions by the way interference occurrences of oscillators. The uncertainty relation of Heisenberg makes sure that the particles are oscillating.

The resultant intensity due to n equally spaced oscillators, all of equal amplitude but different from one another in phase, either because they are driven differently in phase or because we are looking at them an angle such that there is a difference in time delay:

(1) $I = I_0 \sin^2 n\ \phi/2\ \boldsymbol{/}\ \sin^2 \phi/2$

If ϕ is infinitesimal so that $\sin\phi = \phi$, than

(2) $I = n^2\ I_0$

This gives us the idea of

(3) $M_p = n^2\ M_e$

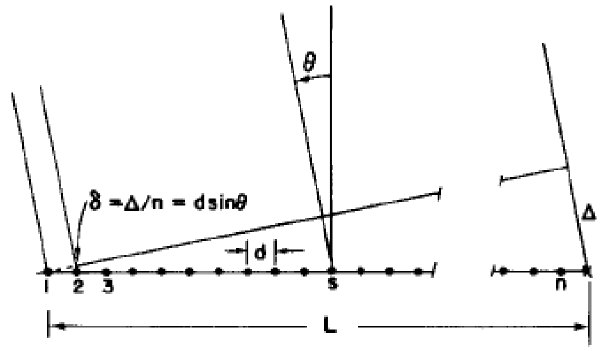


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

Figure 1.) A linear array of n equal oscillators

There is an important feature about formula (1) which is that if the angle ϕ is increased by the multiple of 2π, it makes no difference to the formula.

So

(4) $d \sin \theta = m \lambda$

and we get m-order beam if λ less than d. [6]

If d less than λ we get only zero-order one centered at $\theta = 0$. Of course, there is also a beam in the opposite direction. The right chooses of d and λ we can ensure the conservation of charge.

For example

(5) $2(m+1) = n$

Where $2(m+1) = N_p$ number of protons and $n = N_e$ number of electrons.

In this way we can see the H_2 molecules so that 2n electrons of n radiate to 4(m+1) protons, because $d_e > \lambda_e$ for electrons, while the two protons of one H_2 molecule radiate to two electrons of them, because of $d_e < \lambda_e$ for this two protons.

To support this idea we can turn to the Planck distribution law, that is equal with the Bose – Einstein statistics.

Spontaneously broken symmetry in the Planck distribution law

The Planck distribution law is temperature dependent and it should be true locally and globally. I think that Einstein's energy-matter equivalence means some kind of existence of electromagnetic oscillations enabled by the temperature, creating the different matter formulas, atoms molecules, crystals, dark matter and energy.

Max Planck found for the black body radiation

As a function of wavelength (λ), Planck's law is written as:

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}.$$

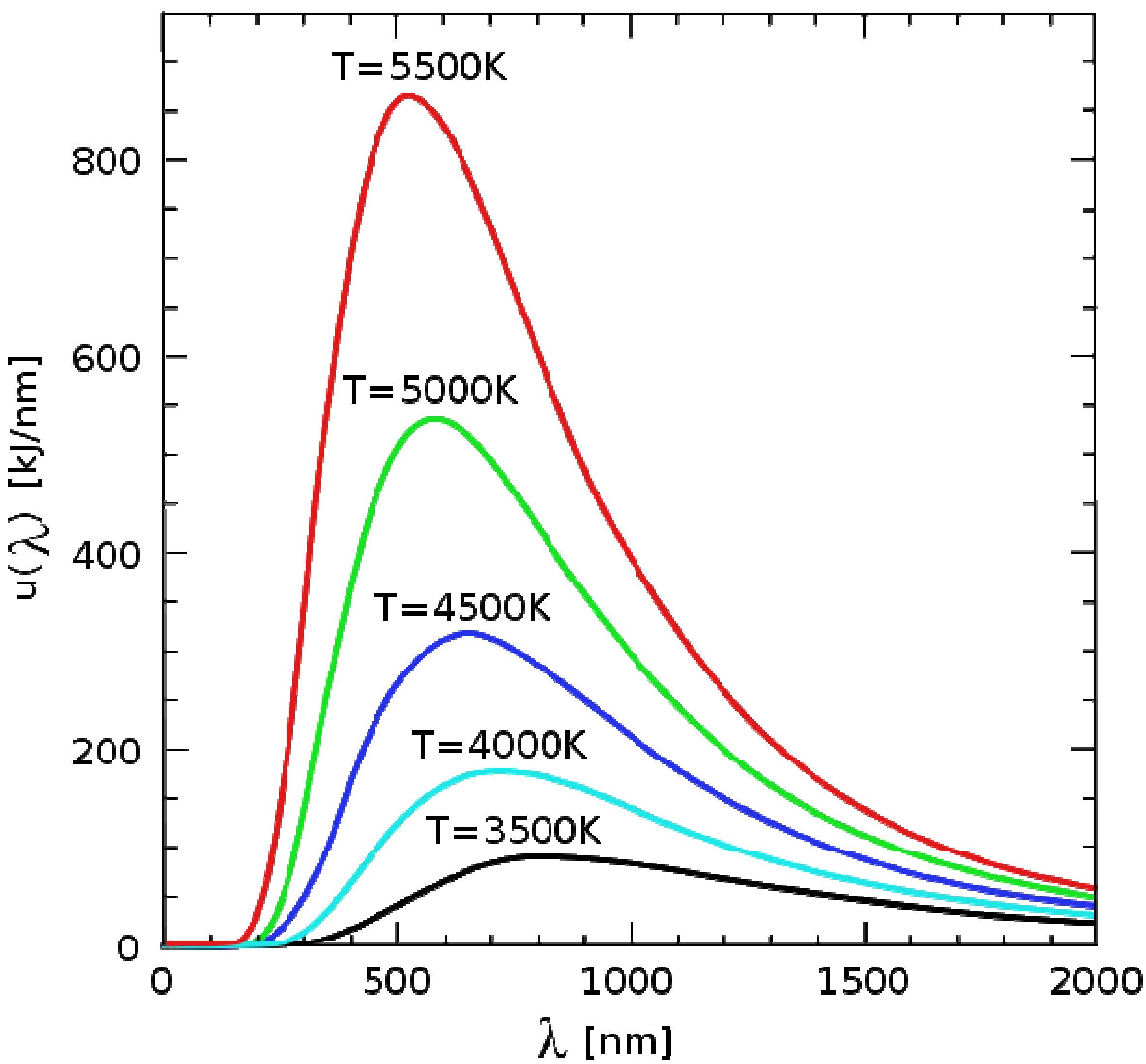


Figure 2. The distribution law for different T temperatures

We see there are two different λ_1 and λ_2 for each T and intensity, so we can find between them a d so that $\lambda_1 < d < \lambda_2$.

We have many possibilities for such asymmetrical reflections, so we have many stable oscillator configurations for any T temperature with equal exchange of intensity by radiation. All of these configurations can exist together. At the λ_{max} is the annihilation point where the configurations are symmetrical. The λ_{max} is changing by the Wien's displacement law in many textbooks.

(7) $$\lambda_{\max} = \frac{b}{T}$$

where λ_{max} is the peak wavelength, T is the absolute temperature of the black body, and b is a constant of proportionality called *Wien's displacement constant*, equal to $2.8977685(51) \times 10^{-3}$ m·K (2002 CODATA recommended value).

By the changing of T the asymmetrical configurations are changing too.

The structure of the proton

We must move to the higher T temperature if we want look into the nucleus or nucleon arrive to $d<10^{-13}$ cm. If an electron with $\lambda_e < d$ move across the proton then by (5) $2(m+1) = n$ with $m = 0$ we get $n = 2$ so we need two particles with negative and two particles with positive charges. If the proton can fraction to three parts, two with positive and one with negative charges, then the reflection of oscillators are right. Because this very strange reflection where one part of the proton with the electron together on the same side of the reflection, the all parts of the proton must be quasi lepton so $d > \lambda_q$. One way dividing the proton to three parts is, dividing his oscillation by the three direction of the space. We can order 1/3 e charge to each coordinates and 2/3 e charge to one plane oscillation, because the charge is scalar. In this way the proton has two +2/3 e plane oscillation and one linear oscillation with -1/3 e charge. The colors of quarks are coming from the three directions of coordinates and the proton is colorless. The flavors of quarks are the possible oscillations differently by energy and if they are plane or linear oscillations. We know there is no possible reflecting two oscillations to each other which are completely orthogonal, so the quarks never can be free, however there is an asymptotic freedom while their energy are increasing to turn them to the orthogonally. If they will be completely orthogonal then they lose this reflection and take new partners from the vacuum. Keeping the symmetry of the vacuum the new oscillations are keeping all the conservation laws, like charge, number of baryons and leptons. The all features of gluons are coming from this model. The mathematics of reflecting oscillators show Fermi statistics.

Important to mention that in the Deuteron there are 3 quarks of +2/3 and -1/3 charge, that is three u and d quarks making the complete symmetry and because this its high stability.

The Pauli Exclusion Principle says that the diffraction points are exclusive!

The Strong Interaction

Confinement and Asymptotic Freedom

For any theory to provide a successful description of strong interactions it should simultaneously exhibit the phenomena of confinement at large distances and asymptotic freedom at short distances. Lattice calculations support the hypothesis that for non-abelian gauge theories the two domains are analytically connected, and confinement and asymptotic freedom coexist.
Similarly, one way to show that QCD is the correct theory of strong interactions is that the coupling extracted at various scales (using experimental data or lattice simulations) is unique in the sense that its variation with scale is given by the renormalization group. [4]
Lattice QCD gives the same results as the diffraction theory of the electromagnetic oscillators, which is the explanation of the strong force and the quark confinement. [1]

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.

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. [5]

Fermions and Bosons

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

The Higgs boson or Higgs particle is a proposed elementary particle in the Standard Model of particle physics. The Higgs boson's existence would have profound importance in particle physics because it would prove the existence of the hypothetical Higgs field - the simplest of several proposed explanations for the origin of the symmetry-breaking mechanism by which elementary particles gain mass. [3]

The fermions' spin

The moving charges are accelerating, since only this way can self maintain the electric field causing their acceleration. The electric charge is not point like! This constant acceleration possible if there is a rotating movement changing the direction of the velocity. This way it can accelerate forever without increasing the absolute value of the velocity in the dimension of the time and not reaching the velocity of the light.

The Heisenberg uncertainty relation says that the minimum uncertainty is the value of the spin: 1/2 h = d x d p or 1/2 h = d t d E, that is the value of the basic energy status.

What are the consequences of this in the weak interaction and how possible that the neutrinos' velocity greater than the speed of light?

The neutrino is the one and only particle doesn't participate in the electromagnetic interactions so we cannot expect that the velocity of the electromagnetic wave will give it any kind of limit.

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 source of the Maxwell equations

The electrons are accelerating also in a static electric current because of the electric force, caused by the potential difference. The magnetic field is the result of this acceleration, as you can see in [2].

The mysterious property of the matter that the electric potential difference is self maintained by the accelerating electrons in the electric current gives a clear explanation to the basic sentence of the relativity that is the velocity of the light is the maximum velocity of the matter. If the charge could move faster than the electromagnetic field than this self maintaining electromagnetic property of the electric current would be failed.

Also an interesting question, how the changing magnetic field creates a negative electric field?
The answer also the accelerating electrons will give. When the magnetic field is increasing in time by

increasing the electric current, then the acceleration of the electrons will increase, decreasing the charge density and creating a negative electric force. Decreasing the magnetic field by decreasing the electric current will decrease the acceleration of the electrons in the electric current and increases the charge density, creating an electric force also working against the change.
In this way we have explanation to all interactions between the electric and magnetic forces described in the Maxwell equations.
The second mystery of the matter is the mass. We have seen that the acceleration change of the electrons in the flowing current causing a negative electrostatic force. This is the cause of the relativistic effect - built-in in the Maxwell equations - that is the mass of the electron growing with its acceleration and its velocity never can reach the velocity of light, because of this growing negative electrostatic force. The velocity of light is depending only on 2 parameters: the magnetic permeability and the electric permittivity.
There is a possibility of the polarization effect created by electromagnetic forces creates the negative and positive charges. In case of equal mass as in the electron-positron pair it is simply, but on higher energies can be asymmetric as the electron-proton pair of neutron decay by week interaction and can be understood by the Feynman graphs.
Anyway the mass can be electromagnetic energy exceptionally and since the inertial and gravitational mass are equals, the gravitational force is electromagnetic force and since only the magnetic force is attractive between the same charges, is very important for understanding the gravitational force.

The Uncertainty Relations of Heisenberg gives the answer, since only this way can be sure that the particles are oscillating in some way by the electromagnetic field with constant energies in the atom indefinitely. Also not by chance that the uncertainty measure is equal to the fermions spin, which is one of the most important feature of the particles. There are no singularities, because 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 greatest proton mass.

The Special Relativity

The mysterious property of the matter that the electric potential difference is self maintained by the accelerating electrons in the electric current gives a clear explanation to the basic sentence of the relativity that is the velocity of the light is the maximum velocity of the matter. If the charge could move faster than the electromagnetic field than this self maintaining electromagnetic property of the electric current would be failed. [8]

The Heisenberg Uncertainty Principle

Moving faster needs stronger acceleration reducing the dx and raising the dp. It means also mass increasing since the negative effect of the magnetic induction, also a relativistic effect!

The Uncertainty Principle also explains the proton – electron mass rate since the dx is much less requiring bigger dp in the case of the proton, which is partly the result of a bigger mass m_p because of the higher electromagnetic induction of the bigger frequency (impulse).

The Gravitational force

The changing magnetic field of the changing current causes electromagnetic mass change by the negative electric field caused by the changing acceleration of the electric charge.

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 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. [1]

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 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]

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 Casimir effect

The Casimir effect is related to the Zero-point energy, which is fundamentally related to the Heisenberg uncertainty relation. The Heisenberg uncertainty relation says that the minimum uncertainty is the value of the spin: 1/2 h = dx dp or 1/2 h = dt dE, that is the value of the basic energy status.
The moving charges are accelerating, since only this way can self maintain the electric field causing their acceleration. The electric charge is not point like! This constant acceleration possible if there is a rotating movement changing the direction of the velocity. This way it can accelerate forever without increasing the absolute value of the velocity in the dimension of the time and not reaching the velocity of the light. 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 is not a point like particle, but has a real charge distribution.

Electric charge and electromagnetic waves are two sides of the same thing; the electric charge is the diffraction center of the electromagnetic waves, quantified by the Planck constant h.

The Fine structure constant

The Planck constant was first described as the proportionality constant between the energy (*E*) of a photon and the frequency (*ν*) of its associated electromagnetic wave. This relation between the energy and frequency is called the **Planck relation** or the **Planck–Einstein equation**:

$$E = h\nu \,.$$

Since the frequency ν, wavelength *λ*, and speed of light *c* are related by *λν* = *c*, the Planck relation can also be expressed as

$$E = \frac{hc}{\lambda}.$$

Since this is the source of Planck constant, the e electric charge countable from the Fine structure constant. This also related to the Heisenberg uncertainty relation, saying that the mass of the proton should be bigger than the electron mass because of the difference between their wavelengths.

The expression of the fine-structure constant becomes the abbreviated

$$\alpha = \frac{e^2}{\hbar c}$$

This is a dimensionless constant expression, 1/137 commonly appearing in physics literature.

This means that the electric charge is a result of the electromagnetic waves diffractions, consequently the proton – electron mass rate is the result of the equal intensity of the corresponding electromagnetic frequencies in the Planck distribution law, described in my diffraction theory.

Path integral formulation of Quantum Mechanics

The path integral formulation of quantum mechanics is a description of quantum theory which generalizes the action principle of classical mechanics. It replaces the classical notion of a single, unique trajectory for a system with a sum, or functional integral, over an infinity of possible trajectories to compute a quantum amplitude. [7]

It shows that the particles are diffraction patterns of the electromagnetic waves.

Conclusions

"The next natural step is then to address few-particle states and electron entanglement in quantum conductors. Again, the question of the destruction of such states by Coulomb interaction effects will be a crucial one." [9]

The magnetic induction creates a negative electric field, causing an electromagnetic inertia responsible for the relativistic mass change; it is the mysterious Higgs Field giving mass to the particles. The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate by the diffraction patterns. The accelerating charges 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 Relativistic Quantum Theories. The self maintained electric potential of the accelerating charges equivalent with the General Relativity space-time curvature, and since it is true on the quantum level also, gives the base of the Quantum Gravity. The electric currents causing self maintaining electric potential is the source of the special and general relativistic effects. The Higgs Field is the result of the electromagnetic induction. The Graviton is two photons together.

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