Magnetic Analog of Liquid Crystals

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Researchers have studied how light can be used to observe the quantum nature of an electronic material. [15]

An international team of researchers led by the National Physical Laboratory (NPL) and the University of Bern has revealed a new way to tune the functionality of next-generation molecular electronic devices using graphene. [14]

Researchers at the Department of Physics, University of Jyväskylä, Finland, have created a theory that predicts the properties of nanomagnets manipulated with electric currents. This theory is useful for future quantum technologies. [13]

Quantum magnetism, in which – unlike magnetism in macroscopic-scale materials, where electron spin orientation is random – atomic spins self-organize into one-dimensional rows that can be simulated using cold atoms trapped along a physical structure that guides optical spectrum electromagnetic waves known as a photonic crystal waveguide. [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

Viewpoint: Closing in on a Magnetic Analog of Liquid Crystals

In 1888, the Austrian chemist Friedrich Reinitzer was trying to measure the melting point of cholesteryl benzoate crystals [1] when, much to his surprise, he observed not one but two phase transitions. Reinitzer had inadvertently discovered liquid crystals. In this cloudy-looking phase, intermittent between a solid and a liquid, the molecules are at random positions but nonetheless break rotational symmetry. The essence of this type of order escaped the physics community until the 1960s, when Pierre-Gilles De Gennes realized that the order parameter describing it could not be expressed as a number (like the density of a gas) or a vector (like the direction of a solid's magnetization), but only by a more complex mathematical entity: a tensor [2]. Soon after, theorists predicted that a quantum version of a common type of order found in liquid crystals, known as nematic order, might be possible in a lattice of spins [3]. Yet besides being observed in condensates of cold atoms [4], spin-nematic order has remained elusive. Among solids, the most promising spin-nematic candidate today is the copper oxide LiCuVO4LiCuVO4 [5]. Thanks to nuclear magnetic resonance (NMR) measurements performed at high magnetic fields, Anna Orlova of France's National Laboratory for Intense Magnetic Fields (LNCMI) and colleagues now provide the strongest evidence to date that LiCuVO4LiCuVO4 indeed exhibits a spin-nematic phase [6].

Like liquid crystals, spin systems are predicted to exhibit different types of nematic phases. The simplest example is the quadrupolar phase of a lattice of spin-1 atoms. The projection of a spin 1 atom onto a given direction, say zz, can take the values -1, 1, or 0. The value of 0 corresponds to a nonmagnetic atom because the quantum expectation values for the spin magnetic moments along xx, yy, and zz are all zero. However, while the expectation value for spin fluctuations along zz also vanishes (?S2z?=0)(<Sz2>=0), those for fluctuations along xx and yy (?S2x?<Sx2> and ?S2y?<Sy2>) do not (Fig. 1, left). When quadrupolar order sets in, all spins are in this nonmagnetic state and fluctuating perpendicular to a fixed direction known as the director, which can vary from site to site. The order can be stabilized by biquadratic interactions between spins and is defined by an order parameter that is a tensor, not a vector.

A similar nematic phase is also possible for spin-1/2 systems, but the physics is more complicated. Locally, any spin-1/2 atom is magnetic because its spin must point up or down along some direction. To form a spin-nematic phase, the spins must therefore somehow pair up to have a spin of 1. This can occur in an interesting way for spin-1/2 atoms in a magnetic field close to "saturation," that is, a field strong enough to fully polarize the spins [7]. In this situation, single-spin flips that propagate through the lattice, called magnons, will usually form a condensate, analogous to a Bose-Einstein condensate of atoms. However, magnons can attract one another, and if this attraction is strong enough, they can form bound states that condense before the single magnons do. In this phase, single spin-flip correlations decay exponentially, but correlations between pairs of spin flips are long-ranged. The order parameter for this phase is defined by a product of two spin operators S+iS+i+1Si+Si+1+, where ii and i+1i+1 are neighboring sites and the ++ denotes a spin flip. The resulting operator is one of the five components of a rank-2 tensor.

The above scenario is thought to happen in LiCuVO4LiCuVO4. In this compound, each copper ion has a spin of 1/2 and interacts strongly only with its closest neighbors along one of the crystal axes, thus forming quasi-1D spin chains. For a field just below saturation along an arbitrary direction, say zz, the predicted spin ground state [7] is a condensate of bound magnons in which pairs of neighboring spins fluctuate around a director that alternately points along xx or yy (Fig. 1, right).

The first experimental evidence for this exotic phase in LiCuVO4LiCuVO4 came in 2011, when a team measured the material's magnetization in a high applied magnetic field. As they lowered the field strength by a few tesla (T) from saturation (which occurs close to 50 T in LiCuVO4LiCuVO4), they observed a kink in the magnetization [5]. They interpreted this feature as indicating a transition from a condensate of bound magnons to one of single magnons.

Orlova et al. have taken a significant step towards confirming that the phase above the kink corresponds to spin-nematic order by showing that it is not magnetically ordered perpendicular to the field (see note in Ref. [8]). In other words, this phase cannot be described by a vector and is therefore probably nematic in nature. To do so, the team performed a tour de force NMR measurement, in which they succeeded in determining the resonant frequencies of the compound's vanadium nuclear spins in fields as high as 55 T by using pulsed fields that lasted a few milliseconds; with today's technology, steady fields can only reach 45 T. The NMR frequency spectrum is very sensitive to the local magnetic field at the vanadium-ion sites, probing the total external field plus any internal field produced by the magnetic moments of the neighboring copper ions. In a nonmagnetic phase, like that expected for spin-nematic ordering, the internal field is the same at every site, so the NMR spectrum consists of a single line that shifts but does not broaden when changing the applied field. By contrast, if the field induces an ordering of the copper spins, different vanadium sites will be exposed to different local fields and the spectral line will broaden into a shape that's indicative of the particular magnetic order. Orlova et al. found that, as they decreased the strength of the pulsed magnetic field to just below saturation, a phase appeared in which the vanadium line shifted but did not broaden with respect to the line above saturation—clearly indicating the absence of magnetic order. No broadening was observed until the field was further reduced and a spin-density phase, known from previous experiments, formed.

Despite this progress, Orlova and colleagues' work doesn't constitute a definitive proof of spin-nematic order, which would require sensitivity to fluctuations of the two-spin operator that defines the order parameter. The most direct way of doing so would be to use a light-scattering probe such as Raman scattering [9]. Alternatively, spin-nematic order has been shown to have specific consequences on spin relaxation rates, which can be measured with NMR, and on the intensity of the Goldstone modes of that phase, known as quadrupolar waves, which can be detected by neutron scattering [10]. However, performing all of these experiments at the necessarily large magnetic fields would be a real challenge. [17]

Magnets, all the way down!

In many ways, magnets are still mysterious. They get their (often powerful) effects from the microscopic interactions of individual electrons, and from the interplay between their collective behavior at different scales. But if you can't move these electrons around to study how factors like symmetry impact the larger-scale magnetic effects, what can you do instead?

It turns out that assemblies of metallic nanoparticles, which can be carefully arranged at multiple length scales, behave like bulk magnets and display intriguing, shape-dependent behavior. The effects, reported this week in the Journal of Applied Physics, from AIP Publishing, could help improve high-density information storage and spintronics technologies.

"The work was inspired by the question [of] how the magnetic interaction between nanoparticles influences the magnetic behavior of the system as a whole, since such array structures are used, for example, in high density storage media," said Alexander Fabian, lead author of the study from Justus-Liebig University Giessen in Germany. "To study the influence of [the] shape of the nanoparticle assemblies, as well as the distance between them, we came up with the idea of a hierarchical design of the samples where the corresponding parameters can be varied systematically."

The round, metallic Fe304 nanocomponents Fabian and his colleagues used in their study were arranged to form differing shapes at three different length scales. Using electron beam lithography, a modernized lithography method that uses electrons to write the desired structure, they configured the nanoparticles into closely-packed shapes, such as triangles, with one side measuring about 10 particles in length. A shaped grid of the smaller-scale configurations, spaced approximately one micron apart, comprised the third hierarchy of the length scales.

"For the preparation of the samples we used lithographic methods, which allow the precise control of the distance and the shape of the nanoparticle assemblies," Fabian said. "For each of the three hierarchical levels, there are two contributions, namely the lattice-like part and the shape-like part.

The high number of possibilities in sample design makes this a challenging aspect to find systems with the most promising physical properties."

The shapes configured at each (sub-)scale were chosen based on their relative symmetries, so as to isolate the effects measured to their causal dimensional scale.

"The symmetries of the lattice and the shapes were here chosen to not interfere with each other. For example, the circular shaped assemblies were combined with different types of lattices," Fabian said. "Assemblies of different shapes, such as triangles, squares or circles, exhibit an angle-dependence of the magnetic anisotropy (direction dependence) corresponding to the shape of the assembly."

With these clever designs, the group was able to demonstrate a large-scale magnet, built from the nanoparticle up. Although their structures acted like bulk ferromagnets, the precise measurements surprised them.

"Our results show that on the chosen length scales, only the shape of the assemblies influences the magnetic behavior, revealing that the assemblies of nanoparticles behave like a single bulk ferromagnet." Fabian said. "Most surprisingly was that the particles seem to behave like a bulk ferromagnet, but with a different magnetization value than that for bulk material, which is an interesting point for future investigations."

Experiments like these can offer valuable, fundamental insight to the latest magnetics-dependent technologies, which make up much of the electronics market. But more fundamentally, these nanoscopically bottom-up approaches are demonstrating controllable means of probing the fundamental fibers comprising bulk and collective electromagnetic properties.

"From a fundamental point of view, it is very interesting to investigate nano systems like nanoparticles. Since they can be fabricated in a very controlled manner, they can also be studied in a systematic approach. Properties of the nanoparticles different from the bulk, or even new properties like superparamagnetism, in nanoparticles make them also interesting for fundamental research." [16]

Observing electrons surfing waves of light on graphene

Researchers have studied how light can be used to observe the quantum nature of an electronic material. They captured light in graphene and slowed it down to the speed of the material's electrons. Then electrons and light started to move in concert, manifesting their quantum nature at such large scale that it could observed with a special type of microscope.

The experiments were performed with ultra-high-quality graphene. To excite and image the ultra-slow ripples of light in the graphene (also called plasmons), the researchers used a special antenna for light that scans the surface at a distance of a few nanometers. With this near-field nanoscope, they saw that the light ripples on the graphene moved more than 300 times more slowly than light, dramatically diverging from what is suggested by classical physics laws.

The work has been published in Science by ICFO researchers Dr. Mark Lundeberg, Dr. Achim Woessner, led by ICREA Prof. at ICFO Frank Koppens, in collaboration with Prof. Hillenbrand from Nanogune, Prof. Polini from IIT and Prof. Hone from Columbia University.

In reference to the accomplished experiments, Prof. Koppens says, "Usually, it is very difficult to probe the quantum world, and to do so requires ultra-low temperatures; here we could observe it with light at room temperature."

This technique paves the way for exploring many new types quantum materials, including superconductors or topological materials that allow for quantum information processing with topological qubits. In addition, Prof. Hillenbrand states that "this could just be the beginning of a new era of near field nanoscopy."

Prof. Polini says, "This discovery may eventually lead to understanding in a truly microscopic fashion complex quantum phenomena that occur when matter is subject to ultra-low temperatures and very high magnetic fields, like the fractional quantum Hall effect." [15]

Graphene offers new functionalities in molecular electronics

An international team of researchers led by the National Physical Laboratory (NPL) and the University of Bern has revealed a new way to tune the functionality of next-generation molecular electronic devices using graphene. The results could be exploited to develop smaller, higher-performance devices for use in a range of applications including molecular sensing, flexible electronics, and energy conversion and storage, as well as robust measurement setups for resistance standards.

The field of nanoscale molecular electronics aims to exploit individual molecules as the building blocks for electronic devices, to improve functionality and enable developers to achieve an unprecedented level of device miniaturization and control. The main obstacle hindering progress in this field is the absence of stable contacts between the molecules and metals used that can both operate at room temperature and provide reproducible results.

Graphene possesses not only excellent mechanical stability, but also exceptionally high electronic and thermal conductive properties, making the emerging 2-D material very attractive for a range of possible applications in molecular electronics.

A team of experimentalists from the University of Bern and theoreticians from NPL (UK) and the University of the Basque Country (UPV/EHU, Spain), with the help of collaborators from Chuo University (Japan), have demonstrated the stability of multi-layer graphene-based molecular electronic devices down to the single molecule limit.

The findings, reported in the journal Science Advances, represent a major step change in the development of graphene-based molecular electronics, with the reproducible properties of covalent contacts between molecules and graphene (even at room temperature) overcoming the limitations of current state-of-the-art technologies based on coinage metals.

Connecting single molecules

Adsorption of specific molecules on graphene-based electronic devices allows device functionality to be tuned, mainly by modifying its electrical resistance. However, it is difficult to relate overall device properties to the properties of the individual molecules adsorbed, since averaged quantities cannot identify possibly large variations across the graphene's surface.

Dr Alexander Rudnev and Dr Veerabhadrarao Kaliginedi, from the Department of Chemistry and Biochemistry at the University of Bern, performed measurements of the electric current flowing though single molecules attached to graphite or multi-layered graphene electrodes using a unique low-noise experimental technique, which allowed them to resolve these molecule-to-molecule variations.

Guided by the theoretical calculations of Dr Ivan Rungger (NPL) and Dr Andrea Droghetti (UPV/EHU), they demonstrated that variations on the graphite surface are very small and that the nature of the chemical contact of a molecule to the top graphene layer dictates the functionality of single-molecule electronic devices.

"We find that by carefully designing the chemical contact of molecules to graphene-based materials, we can tune their functionality," said Dr Rungger. "Our single-molecule diodes showed that the rectification direction of electric current can be indeed switched by changing the nature of chemical contact of each molecule," added Dr Rudnev.

"We are confident that our findings represent a significant step towards the practical exploitation of molecular electronic devices, and we expect a significant change in the research field direction following our path of room-temperature stable chemical bonding," summarised Dr Kaliginedi.

The findings will also help researchers working in electro-catalysis and energy conversion research design graphene/molecule interfaces in their experimental systems to improve the efficiency of the catalyst or device. [14]

Quantum theory for manipulating Nanomagnets

Researchers at the Department of Physics, University of Jyväskylä, Finland, have created a theory that predicts the properties of nanomagnets manipulated with electric currents. This theory is useful for future quantum technologies. The research was published in Physical Review Letters.

How to make faster magnetic memories?

In computer hard drives the information is stored in the magnetic states of small nanomagnets as zeros and ones. "Zero" is thus coded as the south-north magnetization, and "one" as the "north-south" magnetization. Writing information thus requires turning the magnetization, whereas reading it means finding out the magnetization state. The speed of hard drives thus depends on how fast these processes can be realized. The reading process is based on electric currents and therefore can be made fast. On the other hand, writing usually has to be made via magnetic fields, which is much slower. For over 20 years physicists have known a process, spin transfer torque, with which also writing could be realized with the help of electric current. The problem hindering its use in commercial products is the heating this process causes. Because of this heating, the process is more prone to errors. Switching the magnetization state is a stochastic process, which means that the final outcome is not certain. The problem becomes harder as the temperature increases.

Random precession of magnetization

The researchers managed to develop a theory with which to evaluate the probability of the changes in the magnetization in situations where it is manipulated by electric current. The same theory provides the probability of the reciprocal process, spin pumping, where the motion of the magnetization pumps current into the circuit. This latter process is used for radio frequency generation, and also it is stochastic, which means that the pumped current has random fluctuations, noise. In particular, the researchers managed to find out how this noise behaves in the quantum limit of magnetization precession, where the precession frequency is large. Earlier work had concentrated on low frequencies. Therefore, this work will be particularly useful for magnetism-based quantum technologies.

The result is very general and simple, but finding it required the use of complicated theory tools. "Finding the result required a lot of thinking and derivations, but I am very happy with the outcome", tells post-doctoral researcher Pauli Virtanen, now in Scuola Normale Superiore, Pisa, who took care of the detailed calculation. Professor Tero Heikkilä, who provided the idea of the work, continues: "This type of calculation requires a lot of deep intuition. Now our result can be generalized to more complex magnetic structures." [13]

Simulated quantum magnetism can control spin interactions at arbitrary distances

Quantum magnetism, in which – unlike magnetism in macroscopic-scale materials, where electron spin orientation is random – atomic spins self-organize into one-dimensional rows that can be simulated using cold atoms trapped along a physical structure that guides optical spectrum electromagnetic waves known as a photonic crystal waveguide. Recently, scientists at Purdue University, Max-Planck-Institut für Quantenoptik, Germany, and California Institute of Technology, used this approach to devise a scheme for simulating quantum magnetism that provides full control of interactions between pairs of spins at arbitrary distances in 1D and 2D lattices, and moreover demonstrated the scheme's wide utility by generating several well-known spin models. The researchers state that their results allow the introduction of geometric phases into the spin system that could generate topological models with long-range spin–spin interactions.

Dr. Chen-Lung Hung, Dr. Alejandro González-Tudela and Phys.org discussed the study, its challenges and the resulting paper that they have published with their colleagues in Proceedings of the National Academy of Sciences. These challenges included using a two-photon Raman addressing scheme to devise their proposed atom-nanophotonic system – a system that can achieve arbitrary and dynamic control on the strength, phase, and length scale of spin interactions, as well as simulate quantum magnetism with full control of interactions between pairs of spins at arbitrary distances in 1D and 2D lattices. Moreover, the researchers showed that it is possible to introduce geometric phases into the spin system – and thereby realizing topological models with long-range spin–spin interactions – by carefully arranging the propagation phases of Raman beams.

"Cold atoms are an ideal system for studying quantum many-body problems due to their high degree of controllability and reproducibility," González-Tudela and Hung tell Phys.org. "To study various lattice spin models, state-of-the-art experiments load cold atoms into the so-called optical lattices, formed by interfering laser beams in free space. Despite past experimental successes in realizing, for example, superfluid-Mott insulator quantum phase transitions with cold atoms in optical lattices, there are, however, several limitations that preclude cold atoms from emulating a large class of many-body problems involving strong or long-range interactions." This is due to cold atoms being neutral systems that interact very weakly via contact potentials, González-Tudela explains, adding that this small interaction strength makes it difficult to study, for example, important quantum magnetism problems, since these require interactions between atoms in, at least, the adjacent lattice sites. "Decoherence sources can kick in before these very small interaction effects manifest – and on the other hand, short-range interactions also limit the amount of entanglement in the system."

To overcome this challenge and to increase interaction strength, González-Tudela continues, the scientists recently proposed1 to interface cold atoms with structured dielectrics, which with suitable engineering allows increased interaction strengths and range by letting the atoms talk through guided photons in the structure. "However," he points out, "the spatial dependence of the interactions is fixed by the spatial profile of the photon modes and so does not allow for full control in the interactions. This is why, in this paper, we combine our current and previous ideas, employing external magnetic fields and external multi-frequency laser beams to achieve full controllability of spin-spin interactions." In short, these two extra ingredients allow the researchers to achieve not only full control of pair-wise interactions, but also to introduce space-dependent phases through sideband engineering in the control laser beams – and this improved control has important consequences:

The ability to simulate long-range interactions with spatial dependence at will, not just fixed by the photon profile in the material. This has important consequences in the static properties of models that cannot be otherwise investigated, but also in the study of thermalization of closed systems with long-range interactions.

The possibility of introducing space-dependent phases allows the engineering of models with non-trivial topology with long-range interactions, something that is very difficult to obtain in other platforms.

The prospect of modifying boundary conditions at will allow exploration of non-trivial geometries that may give rise to exotic quantum states.

One of the key findings reported in the paper was the new avenues promised by the proposed platform for engineering a large class of spin Hamiltonians, including those exhibiting topological order or frustrated long-range magnetism (in which the atoms whose spin states are giving rise to quantum magnetism cannot settle into a state that minimizes each interaction). "Because the interactions can be engineered at will, many spin model that require long-range spin-exchange or direct spin-spin interactions can be engineered. Frustration phenomena due to competition between long-range spin-exchange and spin-spin interactions can be studied with great details. Moreover, by carefully controlling the optical phases of the external addressing laser beams, we can imprint a quantum mechanical phase on spins that hop along a closed contour. This gives us an opportunity to engineer the so-called geometrical phases in the spin model, which is responsible of inducing topological quantum phases such as quantum Hall states in 2D electron gases.

Another interesting result was showing that atom-nanophotonic systems present appealing platforms to engineer many-body quantum matter by using low-dimensional photons to mediate interaction between distant atom pairs. "Nanophotonic structures provide us a way to engineer the transport property of what we call effectively low-dimensional photons – that is, photons confined in a quasi-2D plane or a 1D wire. When used in nanophotonics, these low-dimensional photons are excellent force- or information-carrying mobile particles that can mediate interactions between distant atom pairs."

Relatedly, the study found that the proposed platform potentially allows for conducting detailed studies on quantum dynamics of long-range, strongly interacting spin systems that are driven out-of-equilibrium. "Dynamic control of interaction strengths is another important feature in our system," Hung points out. "In our Raman control scheme, long-range interaction can be dynamically adjusted via tuning either the amplitude or sidebands in the external control laser beam. Therefore, it will be very easy for the proposed platform to prepare a quantum system out-of-equilibrium and study the subsequent quantum spin dynamics."

On a more encompassing level, the paper states that the scientists expect that their platform may bring novel opportunities to the study of quantum thermalization in long-range many-body systems, or for further understanding of information propagation in a long-range quantum network. Specifically, not only could their platform allow the researchers to study dynamics of a quantum system driven out-of-equilibrium, as mentioned above, but also to investigate how quantum dynamics depends on the range of interactions. "This would provide information on how correlation or entanglement between atomic spins can propagate throughout the spin system, and whether the resulting spin state can still be analyzed as a pure state, or, rather, if it becomes indistinguishable from a statistical mixture," Hung says.

This would therefore provide an opportunity to study quantum thermalization in long-range systems. "Moreover," he continues, "by arbitrary, pairwise engineering of spin-spin interactions, we could establish our model system as a 'miniature' long-range quantum network where atoms are viewed as quantum nodes interconnected via guided photons in the nanophotonic channels. Out-of-equilibrium studies in such systems could provide greater understanding of information propagation in a model quantum network."

Of significant importance to the future capabilities of quantum communications is the development of much more robust resistance to sudden decoherence than now exists. Phys.org therefore asked Hung if their scheme might be a factor in this effort. "Two conditions might lead to sudden decoherence between a pair of local quantum spins – namely, either through coupling to surrounding or distant spins via long-range interactions that we view as an environment, or through dissipative coupling to unwanted nanophotonic channels or to free space. There could be complex behaviors in the engineered spin system, so we may find new surprises."

The paper also discussed the possibility of engineering periodic boundary conditions, as explicitly shown in the 1D Haldane–Shastry model or in other global lattice topologies, by introducing long-range interactions between spins located at the boundaries of a finite system. "Long-range interaction allows us to connect distant spins located at the opposite end of the boundary in a finite system as well as to engineer the connectivity of a local spin to neighboring spins – thereby opening up ways to engineer the global topology of a lattice spin model."

A fascinating aspect of the study discussed in the paper was the possibility of creating previously-unavailable spin-lattice geometries, such as Möbius strip, torus, or lattice models with singular curvatures such as conic geometries that may lead to localized topological states with potential applications in quantum computations. "Boundary conditions and global lattice geometries can play an important role in lattice models exhibiting topological phases," Hung states. "In particular, topological properties manifest as spin transport at the boundaries or near special points with singular lattice curvatures – and these support topological excitations that are stable against local perturbations. Using the proposed platform, especially with arbitrary long-range interactions, we can engineer or even dynamically control the boundary conditions or lattice topologies that are unavailable in other experimental platforms such as cold atoms in optical lattices. This may open up new ways to engineer transport, localization, or even braiding operations of topological excitations," an abstract topological approach to determining quantum operations, "which may find significant applications in topological quantum computations."

In terms of their ongoing research, Hung tells Phys.org that the researchers had great initial successes in developing a prototype alligator photonic crystal2. "Our experimental groups at Caltech and Purdue University are currently developing new nanophotonic platforms with improved optical qualities and band structures that are capable of mediating stronger atom-photon interaction within a large array of trapped atoms to realize the proposed scheme. Another interesting avenue in atom-nanophotonic hybrid system," he continues, "is to use nanostructures and the resulting attractive vacuum forces to form nanoscale lattice potentials for cold atoms. The vacuum force-induced lattice potentials work just as optical lattices in free space for cold atoms, but the lattice spacing – as small as 50 nm – is much smaller than those of the optical lattices, which are limited by the wavelength of interfering lasers. Reduced lattice spacing leads to more than 100 times increased energy scale in the quantum lattice model, improving the low temperature limitation of cold atom experiments. In the long term," González-Tudela concludes, "the possibility of having a platform where long-range interactions can be controlled at will may also impact the simulation of quantum chemistry problems." [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

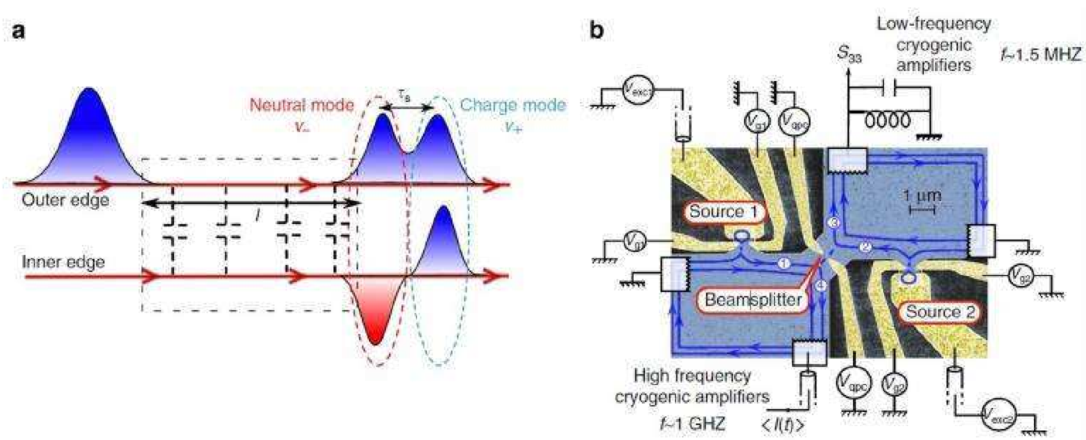
Now in a new paper published in Nature Communications, a team of physicists led by Gwendal Fève at the Ecole Normale Supérieure in Paris and the Laboratory for Photonics and Nanostructures in

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) $I = I_0 \sin^2 n\,\phi/2 \,/\, \sin^2 \phi/2$

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

(2) $I = n^2 I_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

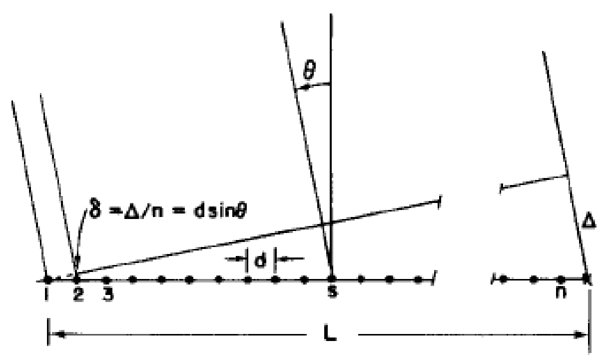


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

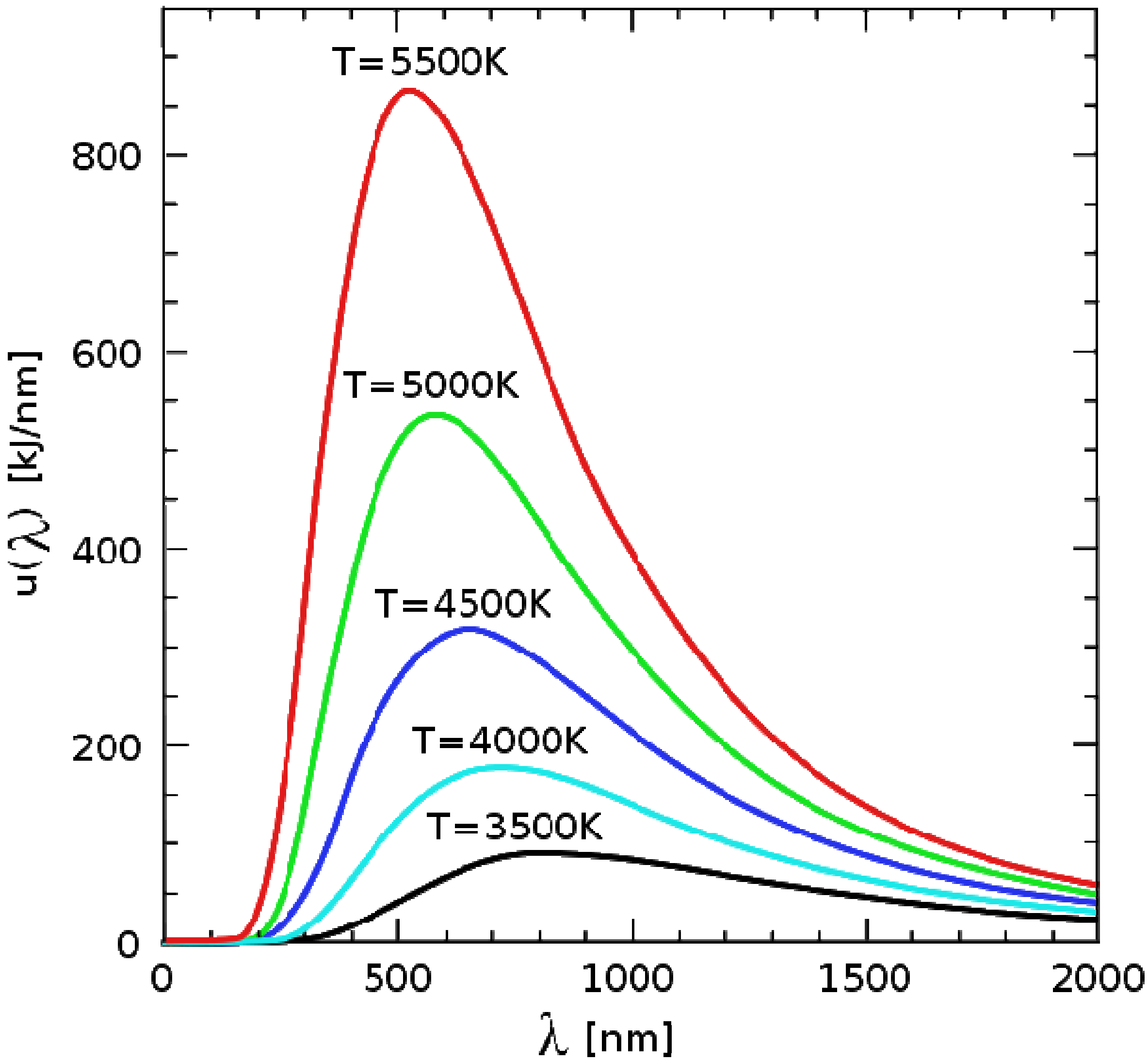


Figure 2. The distribution law for different T temperatures

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 $2.8977685(51)\times10^{-3}$ 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.

References

[1] http://www.academia.edu/3834454/3_Dimensional_String_Theory

[2] http://www.academia.edu/3833335/The_Magnetic_field_of_the_Electric_current

[3] http://www.academia.edu/4158863/Higgs_Field_and_Quantum_Gravity

[4] http://www.academia.edu/4196521/The_Electro-Strong_Interaction

[5] http://www.academia.edu/4221717/General_Weak_Interaction

[6] The Feynman Lectures on Physics p. 274 (30.6)
Author: Richard Phillips Feynman
Publisher: Addison Wesley Longman (January 1970)
ISBN-10: **0201021153** | ISBN-13: **978-0201021158**

[7] Path Integral Formulation of Quantum Mechanics

http://en.wikipedia.org/wiki/Path_integral_formulation

[8] https://www.academia.edu/4215078/Accelerated_Relativity

[9] When an electron splits in two

http://phys.org/news/2015-05-electron.html

[10] Superfast light pulses able to measure response time of electrons to light

http://phys.org/news/2016-02-superfast-pulses-response-electrons.html

[11] Femtosecond Laser pulses push Spintronics and Magnonics to the limit

http://infowebbie.com/scienceupdate/femtosecond-laser-pulses-push-spintronics-and-magnonics-to-the-limit/

[12] Simulated quantum magnetism can control spin interactions at arbitrary distances

http://phys.org/news/2016-08-simulated-quantum-magnetism-interactions-arbitrary.html

[13] Quantum theory for manipulating nanomagnets

https://phys.org/news/2017-06-quantum-theory-nanomagnets.html

[14] Graphene offers new functionalities in molecular electronics

https://phys.org/news/2017-06-graphene-functionalities-molecular-electronics.html

[15] Observing electrons surfing waves of light on graphene

https://phys.org/news/2017-06-electrons-surfing-graphene.html

[16] Magnets, all the way down!

https://phys.org/news/2017-06-magnets.html

[17] Viewpoint: Closing in on a Magnetic Analog of Liquid Crystals

https://physics.aps.org/articles/v10/64