Polarized Light Measure Nonsymmetrical States

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Researchers from Umeå University and Linköping University in Sweden have developed light-emitting electrochemical cells (LECs) that emit strong light at high efficiency. As such, the thin, flexible and lightweight LEC promises future and improved applications within home diagnostics, signage, illumination and healthcare. [17]

Physicists from the ATLAS experiment at CERN have found the first direct evidence of high energy light-by-light scattering, a very rare process in which two photons – particles of light – interact and change direction. [16]

In materials research, chemistry, biology, and medicine, chemical bonds, and especially their dynamic behavior, determine the properties of a system. These can be examined very closely using terahertz radiation and short pulses. [15]

*An international collaborative of scientists has devised a method to control the number of optical solitons in microresonators, which underlie modern photonics. [14]
Solitary waves called solitons are one of nature's great curiosities: Unlike other waves, these lone wolf waves keep their energy and shape as they travel, instead of dissipating or dispersing as most other waves do.*

In a new paper in Physical Review Letters (PRL), a team of mathematicians, physicists and engineers tackles a famous, 50-year-old problem tied to these enigmatic entities. [13]

Theoretical physicists studying the behavior of ultra-cold atoms have discovered a new source of friction, dispensing with a century-old paradox in the process. Their prediction, *which experimenters may soon try to verify, was reported recently in Physical Review Letters. [12]*

Solitons are localized wave disturbances that propagate without changing shape, a result of a nonlinear interaction that compensates for wave packet dispersion. Individual solitons may collide, but a defining feature is that they pass through one another and emerge from the collision unaltered in shape, amplitude, or velocity, but with a new trajectory reflecting a discontinuous jump.

Working with colleagues at the Harvard-MIT Center for Ultracold Atoms, a group led by Harvard Professor of Physics Mikhail Lukin and MIT Professor of Physics Vladan Vuletic have managed to coax photons into binding together to form molecules – a state of matter that, until recently, had been purely theoretical. The work is described in a September 25 paper in Nature.

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

Method with polarized light can create and measure nonsymmetrical states in a layered material

Some molecules, including most of the ones in living organisms, have shapes that can exist in two different mirror-image versions. The right- and left-handed versions can sometimes have different properties, such that only one of them carries out the molecule's functions. Now, a team of physicists has found that a similarly asymmetrical pattern can be induced and measured at will in certain exotic materials, using a special kind of light beam to stimulate the material.

In this case, the phenomenon of "handedness," known as chirality, occurs not in the structure of the molecules themselves, but in a kind of patterning in the density of electrons within the material. The researchers found that this asymmetric patterning can be induced by shining a circularly polarized mid-infrared light at an unusual material, a form of transition-metal dichalcogenide semimetal called TiSe2, or titanium diselenide.

The new findings, which could open up new areas of research in the optical control of quantum materials, are described today in the journal *Nature* in a paper by MIT postdocs Suyang Xu and Qiong Ma, professors Nuh Gedik and Pablo Jarillo-Herrero, and 15 colleagues at MIT and other universities in the U.S., China, Taiwan, Japan, and Singapore.

The team found that while titanium diselenide at room temperature has no chirality to it, as its temperature decreases it reaches a critical point where the balance of right-handed and left-handed electronic configurations gets thrown off and one type begins to dominate. They found that this effect could be controlled and enhanced by shining circularly polarized mid-infrared light at the material, and that the handedness of the light (whether the polarization rotates clockwise or counterclockwise) determines the chirality of the resulting patterning of electron distribution.

"It's an unconventional material, one that we don't fully understand," says Jarillo-Herrero. The material naturally structures itself into "loosely stacked two-dimensional layers on top of each other," sort of like a sheaf of papers, he says.

Within those layers, the distribution of electrons forms a "charge density wave function," a set of ripple-like stripes of alternating regions where the electrons are more densely or less densely packed. These stripes can then form helical patterns, like the structure of a DNA molecule or a spiral staircase, which twist either to the right or to the left.

Ordinarily, the material would contain equal amounts of the right- and left-handed versions of these charge density waves, and the effects of handedness would cancel out in most measurements. But under the influence of the polarized light, Ma says, "we found that we can make the material mostly prefer one of these chiralities. And then we can probe its chirality using another light beam." It's similar to the way a magnetic field can induce a magnetic orientation in a metal where ordinarily its molecules are randomly oriented and thus have no net magnetic effect.

But inducing such an effect in the chirality with light within a solid material is something "nobody ever did before," Gedik explains.

After inducing the particular directionality using the circularly polarized light, "we can detect what kind of chirality there is in the material from the direction of the optically generated electric current," Xu adds. Then, that direction can be switched to the other orientation if an oppositely polarized light source shines on the material.

Gedik says that although some previous experiments had suggested that such chiral phases were possible in this material, "there were conflicting experiments," so it had been unclear until now whether the effect was real. Though it's too early in this work to predict what practical applications such a system might have, the ability to control electronic behavior of a material with just a light beam, he says, could have significant potential.

While this study was carried out with one specific material, the researchers say the same principles may work with other materials as well. The material they used, titanium diselenide, is widely studied for potential uses in quantum devices, and further research on it may also offer insights into the behavior of superconducting materials.

Gedik says that this way of inducing changes in the electronic state of the material is a new tool that could potentially be applied more broadly. "This interaction with light is a phenomenon which will be very useful in other materials as well, not just chiral material, but I suspect in affecting other kinds of orders as well," he says.

And, while chirality is well-known and widespread in biological molecules and in some magnetic phenomena, "this is the first time we've shown that this is happening in the electronic properties of a solid," Jarillo-Herrero says.

"The authors found two new things," says Jasper van Wezel, a professor at the University of Amsterdam, who was not part of the research team. He said the new findings are "a new way of testing whether or not a material is chiral, and a way of enhancing the overall chirality in a big piece of material. Both breakthroughs are significant. The first as an addition to the experimental toolbox of materials scientists, the second as a way of engineering materials with desirable properties in terms of their interaction with light." [21]

Portable polarization-sensitive camera could be used in machine vision, autonomous vehicles, security and more

When the first full-length movie made with the advanced, three-color process of Technicolor premiered in 1935, The New York Times declared "it produced in the spectator all the excitement of standing upon a peak ... and glimpsing a strange, beautiful and unexpected new world."

Technicolor forever changed how cameras—and people—saw and experienced the world around them. Today, there is a new precipice—this one, offering views of a polarized world.

Polarization, the direction in which light vibrates, is invisible to the human eye (but visible to some species of shrimp and insects). But it provides a great deal of information about the objects with which it interacts. Cameras that see polarized light are currently used to detect material stress, enhance contrast for object detection, and analyze surface quality for dents or scratches.

However, like the early color cameras, current-generation polarization-sensitive cameras are bulky. Moreover, they often rely on moving parts and are costly, severely limiting the scope of their potential application.

Now, researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have developed a highly compact, portable camera that can image polarization in a single shot. The miniature camera—about the size of a thumb—could find a place in the vision systems of autonomous vehicles, onboard planes or satellites to study atmospheric chemistry, or be used to detect camouflaged objects.

Polarization, the direction in which light vibrates, is invisible to the human eye but provides a lot of information about the objects with which it interacts. For example, polarized light highlights the defects in this plastic spoon. Credit: Harvard SEAS

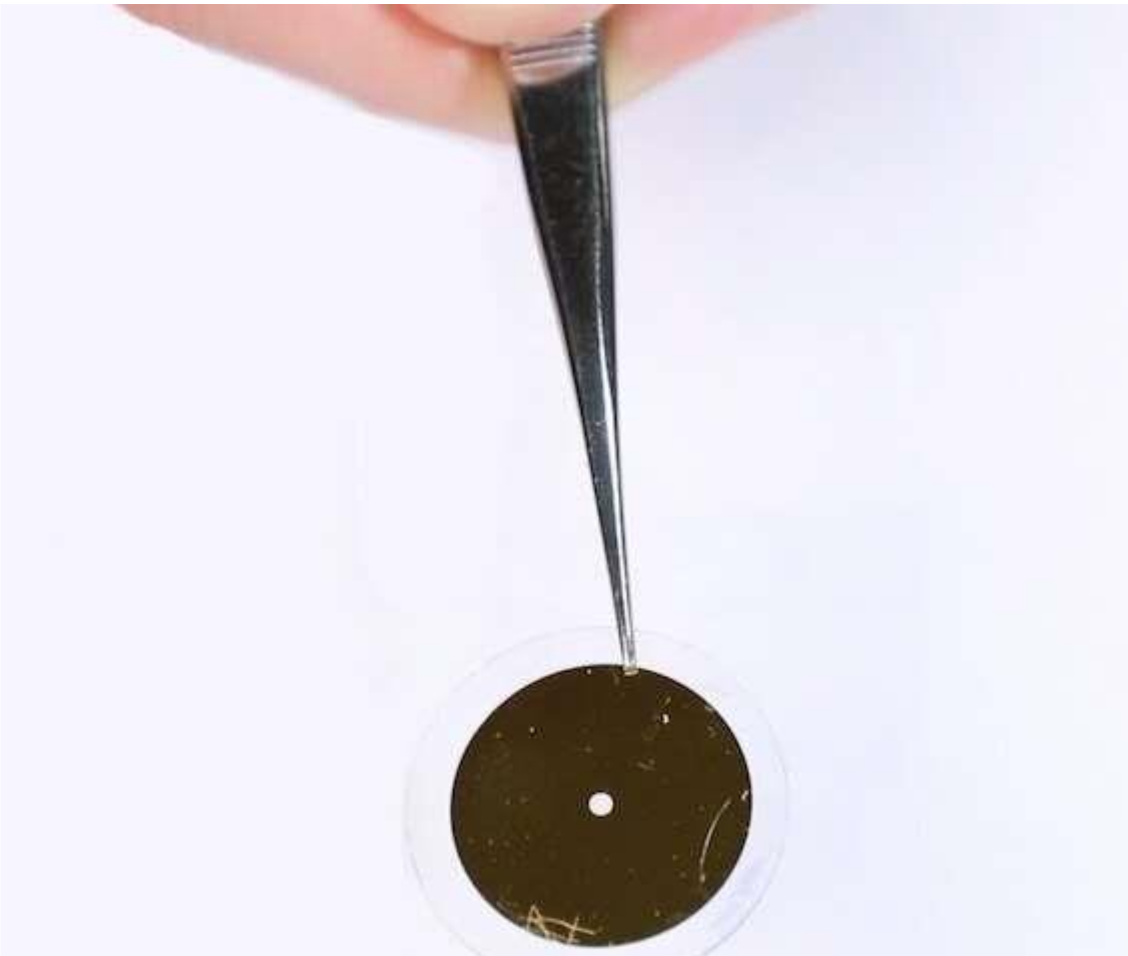
The research is published in *Science*.

"This research is game-changing for imaging," said Federico Capasso, the Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering at SEAS and senior author of the paper. "Most cameras can typically only detect the intensity and color of light but can't see polarization. This camera is a new eye on reality, allowing us to reveal how light is reflected and transmitted by the world around us."

"Polarization is a feature of light that is changed upon reflection off a surface," said Paul Chevalier, a postdoctoral fellow at SEAS and co-author of the study. "Based on that change, polarization can help us in the 3-D reconstruction of an object, to estimate its depth, texture and shape, and to distinguish man-made objects from natural ones, even if they're the same shape and color."

To unlock that powerful world of polarization, Capasso and his team harnessed the potential of metasurfaces, nanoscale structures that interact with light at wavelength size-scales.

"If we want to measure the light's full polarization state, we need to take several pictures along different polarization directions," said Noah Rubin, first author of the paper and graduate student in the Capasso Lab. "Previous devices either used moving parts or sent light along multiple paths to acquire the multiple images, resulting in bulky optics. A newer strategy uses specially patterned camera pixels, but this approach does not measure the full polarization state and requires a non-standard imaging sensor. In this work, we were able to take all of the optics needed and integrate them in a single, simple device with a metasurface."


The portable polarization camera is about two centimeters in diameter and uses a metasurface with an array of subwavelength spaced nanopillars to direct light based on its polarization. Credit: Eliza Grinnell/Harvard SEAS

Using a new understanding how polarized light interacts with objects, the researchers designed a metasurface that uses an array of subwavelength spaced nanopillars to direct light based on its polarization. The light then forms four images, each one showing a different aspect of the polarization. Taken together, these give a full snapshot of polarization at every pixel.

The device is about two centimeters in length and no more complicated than a camera on a smartphone. With an attached lens and protective case, the device is about the size of a small lunch box. The researchers tested the camera to show defects in injection-molded plastic objects, took it outside to film the polarization off car windshields and even took selfies to demonstrate how a polarization camera can visualize the 3-D contours of a face.

"This technology could be integrated into existing imaging systems, such as the one in your cell phone or car, enabling the widespread adoption of polarization imaging and new applications previously unforeseen," said Rubin.

"This research opens an exciting new direction for camera technology with unprecedented compactness, allowing us to envision applications in atmospheric science, remote sensing, facial recognition, machine vision and more," said Capasso. [20]

Compact camera measures light polarization in full

A compact and simple camera that can determine the full polarization of light has been developed by researchers in the US. The device uses a metasurface patterned with nanopillars to split incoming light into its four Stokes polarization parameters and then measures each one simultaneously. The team says that the technology could be used in a wide range of applications including remote sensing and facial recognition.

Put on a pair of polarizing sunglasses – which block horizontally-polarized light – and the world looks a bit different. If you look at the rear windows of some cars for example, you will notice a grid-like pattern that is normally invisible to the naked eye. The glasses are revealing stresses manufactured into the glass to ensure that it shatters safely. This is just one example of how measuring the polarization of light can reveal useful information about a material.

While blocking light of a certain polarization is relatively simple, determining the full polarization of light involves making separate measurements of four "Stokes parameters". This is normally done using bulky optical systems that have moving parts and limited temporal resolution.

Matrix Fourier optics

To make Stokes measurements easier, Federico Capasso and colleagues at Harvard University have developed a new way of describing how the polarization of light interacts with optical systems. Dubbed "matrix Fourier optics", the technique was then used by the team to create a nanostructured metasurface of tiny pillars that directs incident light according to its polarization. The metasurface can separate light into its four Stokes components, creating four separate images of an object. These images are then detected simultaneously and the information used to determine the full polarization of the light from the object.

The new device is about 2 cm long and the researchers say that it is no more complicated than a smartphone camera. The team showed that the device can measure the full Stokes polarization of light reflected from a number of different objects. This was demonstrated indoors using artificial illumination and outdoors using daylight.

Depth, texture and shape

"Polarization is a feature of light that is changed upon reflection off a surface," says Harvard's Paul Chevalier. "Based on that change, polarization can help us in the 3D reconstruction of an object, to estimate its depth, texture and shape, and to distinguish manmade objects from natural ones, even if they're the same shape and colour."

Daguerreotypes reveal their plasmonic secrets

Team member Noah Rubin adds, "This technology could be integrated into existing imaging systems, such as the one in your cell phone or car, enabling the widespread adoption of polarization imaging and new applications previously unforeseen".

Capasso says that potential applications of the new camera include atmospheric science, remote sensing, facial recognition and machine vision.

The new camera is described in Science. [19]

Accelerating light beams in curved space

By shining a laser along the inside shell of an incandescent light bulb, physicists have performed the first experimental demonstration of an accelerating light beam in curved space. Rather than moving along a geodesic trajectory (the shortest path on a curved surface), the accelerating beam bends away from the geodesic trajectory as a result of its acceleration.

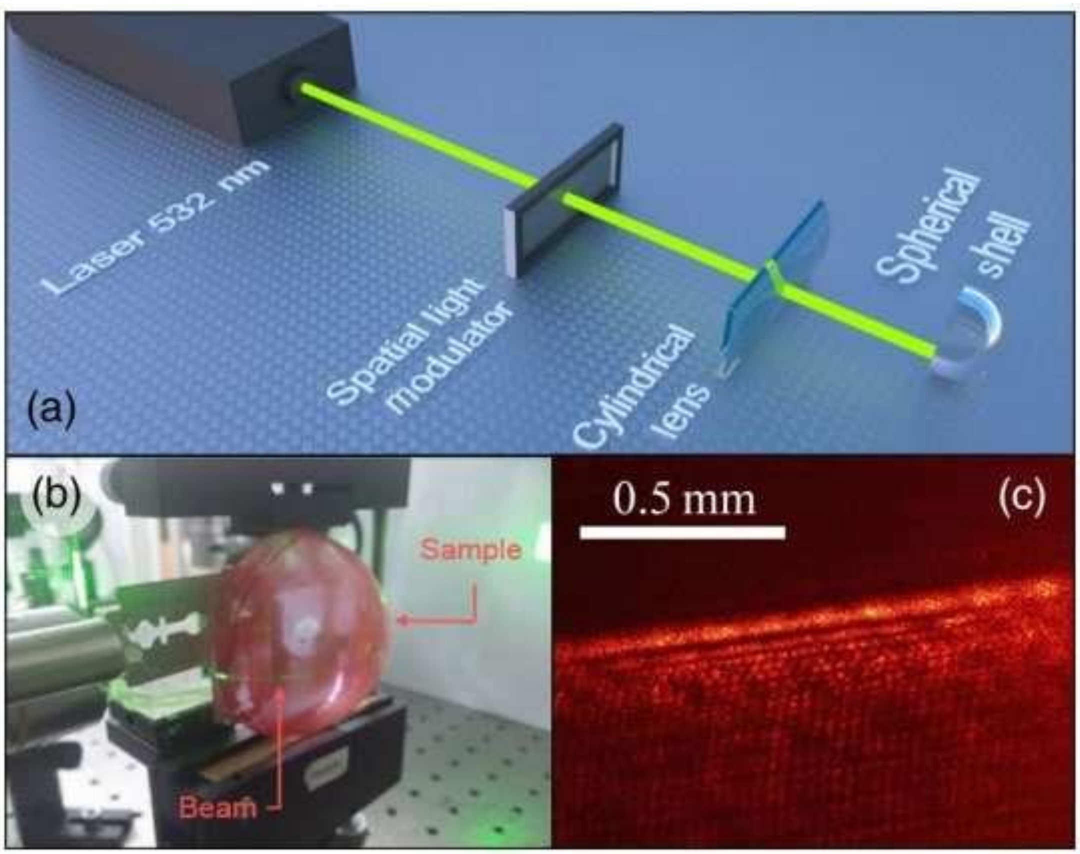
Previously, accelerating light beams have been demonstrated on flat surfaces, on which their acceleration causes them to follow curved trajectories rather than straight lines. Extending accelerating beams to curved surfaces opens the doors to additional possibilities, such as emulating general relativity phenomena (for example, gravitational lensing) with optical devices in the lab.

The physicists, Anatoly Patsyk, Miguel A. Bandres, and Mordechai Segev at the Technion – Israel Institute of Technology, along with Rivka Bekenstein at Harvard University and the Harvard-Smithsonian Center for Astrophysics, have published a paper on the accelerating light beams in curved space in a recent issue of *Physical Review X*.

"This work opens the doors to a new avenue of study in the field of accelerating beams," Patsyk told *Phys.org*. "Thus far, accelerating beams were studied only in a medium with a flat geometry, such as flat free space or slab waveguides. In the current work, optical beams follow curved trajectories in a curved medium."

In their experiments, the researchers first transformed an ordinary laser beam into an accelerating one by reflecting the laser beam off of a spatial light modulator. As the scientists explain, this imprints a specific wavefront upon the beam. The resulting beam is both accelerating and shape-preserving, meaning it doesn't spread out as it propagates in a curved medium, like ordinary light beams would do. The accelerating light beam is then launched into the shell of an incandescent light bulb, which was painted to scatter light and make the propagation of the beam visible.

When moving along the inside of the light bulb, the accelerating beam follows a trajectory that deviates from the geodesic line. For comparison, the researchers also launched a nonaccelerating beam inside the light bulb shell, and observed that that beam follows the geodesic line. By measuring the difference between these two trajectories, the researchers could determine the acceleration of the accelerating beam.



(a) Experimental setup, (b) propagation of the green beam inside of the red shell of an incandescent light bulb, and (c) photograph of the lobes of the accelerating beam. Credit: Patsyk et al. ©2018 American Physical Society

Whereas the trajectory of an accelerating beam on a flat surface is determined entirely by the beam width, the new study shows that the trajectory of an accelerating beam on a spherical surface is determined by both the beam width and the curvature of the surface. As a result, an accelerating beam may change its trajectory, as well as periodically focus and defocus, due to the curvature.

The ability to accelerate light beams along curved surfaces has a variety of potential applications, one of which is emulating general relativity phenomena.

"Einstein's equations of general relativity determine, among other issues, the evolution of electromagnetic waves in curved space," Patsyk said. "It turns out that the evolution of electromagnetic waves in curved space according to Einstein's equations is equivalent to the propagation of electromagnetic waves in a material medium described by the electric and magnetic susceptibilities that are allowed to vary in space. This is the foundation of emulating numerous phenomena known from general relativity by the electromagnetic waves propagating in a material medium, giving rise to the emulating effects such as gravitational lensing and Einstein's rings, gravitational blue shift or red shift, which we have studied in the past, and much more."

The results could also offer a new technique for controlling nanoparticles in blood vessels, microchannels, and other curved settings. Accelerating plasmonic beams (which are made of plasma oscillations instead of light) could potentially be used to transfer power from one area to another on a curved surface. The researchers plan to further explore these possibilities and others in the future.

"We are now investigating the propagation of light within the thinnest curved membranes possible—soap bubbles of molecular thickness," Patsyk said. "We are also studying linear and nonlinear wave phenomena, where the laser beam affects the thickness of the membrane and in return the membrane affects the light beam propagating within it." [17]

The LEC—now an efficient and bright device

Researchers from Umeå University and Linköping University in Sweden have developed light-emitting electrochemical cells (LECs) that emit strong light at high efficiency. As such, the thin, flexible and lightweight LEC promises future and improved applications within home diagnostics, signage, illumination and healthcare. The results are published in *Nature Communications*.

The light-emitting electrochemical cell (LEC) can be thin, flexible, and light-weight and be driven to essentially any emission color by the low voltage of a battery. It can also be extremely low cost, since it can be fabricated with low-cost printing and coating methods similar to how newspapers are fabricated.

A persistent problem is that it has not been possible to attain strong brightness at high efficiency from LEC devices. In fact, it has been questioned whether the LEC is even capable of being simultaneously bright and efficient. In the current issue of *Nature Communications*, a team of scientists demonstrate a path toward resolving this problem. Using a systematic combination of experiments and simulations, they have established a generic set of design principles, including balanced trap depths, optimized doping, and electrochemically stabile materials. The approach has paved the way for LEC devices that emit light with a high brightness of 2,000 cd/m^2 at an electron-to-photon efficiency of 27.5 percent.

"As a point of reference, a normal TV operates between 300 to 500 cd/m^2, while 2,000 cd/m^2 is the typical brightness of an OLED illumination panel. Concerning efficiency, our LEC device is close to that of common fluorescent tubes," says Ludvig Edman, leader of the project and professor at the department of physics at Umeå University.

"With this performance, the LEC component is now not only offering low costs and highly attractive design advantages, but is also becoming a true competitor with existing technologies, such as the fluorescent tube, LED and OLED, as regards to efficient and practical operation," says Martijn Kemerink, professor at the department of physics, chemistry and biology at Linköping University. [17]

ATLAS observes direct evidence of light-by-light scattering

Physicists from the ATLAS experiment at CERN have found the first direct evidence of high energy light-by-light scattering, a very rare process in which two photons – particles of light – interact and change direction. The result, published today in Nature Physics, confirms one of the oldest predictions of quantum electrodynamics (QED).

"This is a milestone result: the first direct evidence of light interacting with itself at high energy," says Dan Tovey(University of Sheffield), ATLAS Physics Coordinator. "This phenomenon is impossible in classical theories of electromagnetism; hence this result provides a sensitive test of our understanding of QED, the quantum theory of electromagnetism."

Direct evidence for light-by-light scattering at high energy had proven elusive for decades – until the Large Hadron Collider's second run began in 2015. As the accelerator collided lead ions at unprecedented collision rates, obtaining evidence for light-by-light scattering became a real possibility. "This measurement has been of great interest to the heavy-ion and high-energy physics communities for several years, as calculations from several groups showed that we might achieve a significant signal by studying lead-ion collisions in Run 2," says Peter Steinberg (Brookhaven National Laboratory), ATLAS Heavy Ion Physics Group Convener.

Heavy-ion collisions provide a uniquely clean environment tostudy light-by-light scattering. As bunches of lead ions are accelerated, an enormous flux of surrounding photons is generated. When ions meet at the centre of the ATLAS detector, very few collide, yet their surrounding photons can interact and scatter off one another. These interactions are known as 'ultra-peripheral collisions'.

Studying more than 4 billion events taken in 2015, the ATLAS collaboration found 13 candidates for light-by-light scattering. This result has a significance of 4.4 standard deviations, allowing the ATLAS collaboration to report the first direct evidence of this phenomenon at high energy.

"Finding evidence of this rare signature required the development of a sensitive new 'trigger' for the ATLAS detector," says Steinberg. "The resulting signature—two photons in an otherwise empty detector—is almost the diametric opposite of the tremendously complicated eventstypically expected from lead nuclei collisions. The new trigger's success in selecting these events demonstrates the power and flexibility of the system, as well as the skill and expertise of the analysis and trigger groups who designed and developed it."

ATLAS physicists will continue to study light-by-light scattering during the upcoming LHC heavy-ion run, scheduled for 2018. More data will further improve the precision of theresult and may open a new window to studies of new physics. In addition, the study of ultra-peripheral collisions should play a greater role in the LHC heavy-ion programme, as collision rates further increase in Run 3 and beyond. [16]

Inspecting matter using terahertz light

In materials research, chemistry, biology, and medicine, chemical bonds, and especially their dynamic behavior, determine the properties of a system. These can be examined very closely using terahertz radiation and short pulses. KIT's FLUTE accelerator will be used for the development of new accelerator technologies for compact and powerful terahertz sources that are supposed to serve as efficient research and application tools.

"The KIT scientists excel in their ability to come up with creative ideas and explore new fields of application," as Professor Holger Hanselka, President of KIT, points out. "With the compact FLUTE accelerator, KIT opens the door to a new tool that will enable biologists, analytical chemists, and materials scientists to obtain outstanding insights."

The FLUTE facility (this abbreviation is derived from its German name: Ferninfrarot Linac- und TestExperiment) is a development platform for accelerator physics studies. It will serve as a test facility for methods that allow, in a first step, to better understand, measure, and control the complex dynamics of ultra-short electron bunches. Only very compact electron bunches can generate intensive, brilliant, and coherent terahertz radiation. The special challenge faced when designing accelerators such as FLUTE is to keep the electron cloud so compact during the acceleration process that its expansion is smaller than the wavelength of the generated electromagnetic radiation. Only then, the waves overlap each other, forming pulses of high intensity with a duration of picoseconds or femtoseconds.

In the long run, control of the electron bunches must be improved in such a way that the terahertz radiation can be adapted perfectly to the intended application. Terahertz radiation could open up new domains of application for which the neighboring visible light and radio waves are unsuitable. As a research infrastructure, FLUTE will also be used for the development of terahertz radiation measuring methods that can be employed in materials and life sciences. Protein oscillations can be examined just as well as the behavior of superconductors or novel semiconductors.

Within the FLUTE accelerator, whose length is approx. 12 meters, the electrons are accelerated to reach an energy of up to 50 MeV. The electron cloud is compressed to a few micrometers so that radiation with a frequency of 30 terahertz or more can be generated. Besides the Institute for Beam Physics and Technology at KIT, development partners from all over Europe, above all the Swiss Paul Scherrer Institute (PSI), participate in the FLUTE project. [15]

Scientists develop new method of high-precision optical measurement

An international collaborative of scientists has devised a method to control the number of optical solitons in microresonators, which underlie modern photonics.

Photonics is a dynamically developing field of modern physics. Microresonators are basic structural elements of photonics, an integral part of almost all sophisticated optical and microwave devices. In fact, resonators are circular light traps. Microresonators are currently used for laser stabilization and optical filters.

In their research, the results of which are published in Nature Physics, the scientists have addressed the problem of stable optical pulse generation in resonators—in other words, to ensure that every pulse (soliton) put into it persists for a long period of time. The second experimental aim was to reduce the number of soliton pulses moving in a resonator to one. At the same time, the outgoing emission spectrum has the appearance of a super-stable optical frequency comb, which could be used as a high-precision ruler for optical spectra.

Grigory Lichachev, a doctoral student at the Faculty of Physics, said, "Pulses should live for a long period of time, and it should be only one, not several pulses.

When there is only one pulse, it has the clearest spectrum, known as a comb, which has many applications, for instance, in spectroscopy."

The scientists studied two optical resonators on a chip base only one micron thick. The first one was made out of optical crystal, magnesium fluoride (MgF_2); the second one out of silicon nitride (Si_3N_4).

A laser was introduced light into the resonator, and the properties of its pulses were measured at output with the help of spectrometer.

The experiment demonstrated a method that forms one pulse, which propagates around in a resonator. Physicists observed a regular spectral comb, which is the distinguishing characteristic of a soliton. Moreover, the article shows a new and very effective method worked out by scientists to observe solitons in real-time. This was achieved by the addition of weak phase modulation to the input signal and further response registration to this disturbance. Such an approach opens up new possibilities for maintaining and stabilizing combs.

The technique worked out by the scientists actuates an unknown large number of solitons in a resonator and then sequentially reduces this number to a single pulse.

The scientists emphasize that the reduction of extra solitons sequentially becomes possible only due to the change of laser frequency used for actuating the resonator.

The optical frequency comb is the foundation of the laser-based precision spectroscopy technique, which was awarded the Nobel Prize for Physics in 2005.

Applications include astronomy and high-precision sensors, for instance, to measure the spectrum of an unknown substance. Using two identical optical solitons and overlapping their optical frequency combs, scientists could measure optical frequencies, which could not be measured directly because of their size.

Potential applications of this method include the measurement of gas composition using spectroscopy in the mid-infrared range. By directing two optical solitons to the experimental gas through a common optical fiber, scientists could observe notches, connected with specific absorption lines, in the spectrum output.

Usage of two solitons allows scientists to measure frequencies in radio waves beyond the optical range. If it takes seconds to measure frequencies in an optical spectrometer, then in the microwave range, the measurement time is nanoseconds. [14]

Study solves 50-year-old puzzle tied to enigmatic, lone wolf waves

Solitary waves called solitons are one of nature's great curiosities: Unlike other waves, these lone wolf waves keep their energy and shape as they travel, instead of dissipating or dispersing as most other waves do.

In a new paper in Physical Review Letters (PRL), a team of mathematicians, physicists and engineers tackles a famous, 50-year-old problem tied to these enigmatic entities.

The puzzle dates back to 1965, when physicists Norman Zabusky and Martin Kruskal came up with a surprising solution to the Korteweg-de Vries equation, which serves as a mathematical model for describing nonlinear waves in shallow water.

Using a computer, Zabusky and Kruskal generated an approximate solution to the equation that featured eight independent, particle-like waves. Each of these waves retained its form and speed over time and distance—even after colliding with other such waves. The colleagues coined the term "soliton" to describe these unusual entities, giving birth to modern research in this field.

Kruskal and others then went on to invent a new mathematical method to solve the Korteweg-de Vries equation exactly. However, the calculations needed to obtain concrete answers are complex, typically requiring the use of a computer to complete—thus limiting scientists' ability to understand phenomena, including Zabusky and Kruskal's 1965 solution, says University at Buffalo mathematician Gino Biondini.

Moreover, to Biondini's knowledge, the original wave pattern that Zabusky and Kruskal described in 1965 has never been fully reproduced in the physical world (though earlier experiments have managed to generate portions of the solution).

The new PRL study, published Sept. 28, addresses both of these problems, says Biondini, a co-author on the paper.

A new approach to an old problem

With Guo Deng, a UB PhD candidate in physics, Biondini developed a mathematical approach that produces an approximate solution to the equation that Zabusky and Kruskal tackled in the 1960s. The new approach enables researchers to make explicit, accurate predictions about how many solitons will emerge in a given setting, as well as what features these waves will have, such as their amplitude and speed.

The method's simplicity means that researchers can use it to gain a better mathematical understanding of soliton formation in these kinds of situations, Biondini says.

"Zabusky and Kruskal's famous work from the 1960s gave rise to the field of soliton theory," says Biondini, a professor of mathematics in the UB College of Arts and Sciences. "But until now, we lacked a simple explanation for what they described. Our method gives you a full description of the solution that they observed, which means we can finally gain a better understanding of what's happening."

Making waves

While Biondini and Deng worked on the theoretical side of the problem, colleagues in Europe and Japan put their math to the test in real-world experiments as part of the same paper.

Led by Italian scientists Miguel Onorato and Stefano Trillo of the University of Turin and the University of Ferrara, respectively, the team ran experiments in a 110-meter-long water tank in Berlin using a computer-assisted wave generator. The wave patterns they produced matched well with Biondini and Deng's predictions, and included the original eight-soliton solution described by Zabusky and Kruskal so many years before (though it should be noted that water waves do begin to lose some energy after traveling over long distances, and are therefore only approximately solitons).

"Previous experiments had produced parts of the famous results from 1965, but, as far as I know, they all had limitations," Onorato says. "We were able to generate the solution more fully, including all eight solitons. We were also able to experimentally generate another feature observed in multisoliton solutions, namely the strange phenomenon of recurrence, in which a wave pattern transitions from its initial state to a state with several solitons and back again to the original state. This is akin to placing a bunch of children in a room to play, then returning later to find that the room has been returned to its initial, tidy state after a period of messiness." [13]

Ultra-cold atoms may wade through quantum friction

Theoretical physicists studying the behavior of ultra-cold atoms have discovered a new source of friction, dispensing with a century-old paradox in the process. Their prediction, which experimenters may soon try to verify, was reported recently in Physical Review Letters.

The friction afflicts certain arrangements of atoms in a Bose-Einstein Condensate (BEC), a quantum state of matter in which the atoms behave in lockstep. In this state, well-tuned magnetic fields can cause the atoms to attract one another and even bunch together, forming a single composite particle known as a soliton.

Solitons appear in many areas of physics and are exceptionally stable. They can travel freely, without losing energy or dispersing, allowing theorists to treat them like everyday, non-quantum objects. Solitons composed of photons—rather than atoms—are even used for communication over optical fibers.

Studying the theoretical properties of solitons can be a fruitful avenue of research, notes Dmitry Efimkin, the lead author of the paper and a former JQI postdoctoral researcher now at the University of Texas at Austin. "Friction is very fundamental, and quantum mechanics is now quite a well-tested theory," Efimkin says. "This work investigates the problem of quantum friction for solitons and marries these two fundamental areas of research."

Efimkin, along with JQI Fellow Victor Galitski and Johannes Hofmann, a physicist at the University of Cambridge, sought to answer a basic question about soliton BECs: Does an idealized model of a soliton have any intrinsic friction?

Prior studies seemed to say no. Friction arising from billiard-ball-like collisions between a soliton and stray quantum particles was a possibility, but the mathematics prohibited it. For a long time, then, theorists believed that the soliton moved through its cloudy quantum surroundings essentially untouched.

But those prior studies did not give the problem a full quantum consideration, Hofmann says. "The new work sets up a rigorous quantum-mechanical treatment of the system," he says, adding that this theoretical approach is what revealed the new frictional force.

It's friction that is familiar from a very different branch of physics. When a charged particle, such as an electron, is accelerated, it emits radiation. A long-known consequence is that the electron will experience a friction force as it is accelerated, caused by the recoil from the radiation it releases.

Instead of being proportional to the speed of the electron, as is friction like air resistance, this force instead depends on the jerk—the rate at which the electron's acceleration is changing. Intriguingly, this is the same frictional force that appears in the quantum treatment of the soliton, with the soliton's absorption and emission of quantum quasiparticles replacing the electron's emission of radiation.

At the heart of this frictional force, however, lurks a problem. Including it in the equations describing the soliton's motion—or an accelerated electron's—reveals that the motion in the present depends on events in the future, a result that inverts the standard concept of causality. It's a situation that has puzzled physicists for decades.

The team tracked down the origin of these time-bending predictions and dispensed with the paradox. The problem arises from a step in the calculation that assumes the friction force only depends on the current state of the soliton. If, instead, it also depends on the soliton's past trajectory, the paradox disappears.

Including this dependence on the soliton's history leads to nearly the same equations governing its motion, and those equations still include the new friction. It's as if the quantum background retains a memory of the soliton's path.

Hofmann says that BECs provide a pristine system to search for the friction. Experimenters can apply lasers that set the atomic soliton in motion, much like a marble rolling around a bowl—although the bowl is tightly squeezed in one dimension. Observing the frequency and amplitude of this motion, as well as how it changes over time, could reveal the friction's signature. "Using some typical experimental parameters, we think that the magnitude of this force is large enough to be observable in current experiments," Hofmann says. [12]

'Matter waves' move through one another but never share space

Physicist Randy Hulet and colleagues observed a strange disappearing act during collisions between forms of Bose Einstein condensates called solitons. In some cases, the colliding clumps of matter appear to keep their distance even as they pass through each other. How can two clumps of matter pass through each other without sharing space? Physicists have documented a strange disappearing act by colliding Bose Einstein condensates that appear to keep their distance even as they pass through one another.

BECs are clumps of a few hundred thousand lithium atoms that are cooled to within one-millionth of a degree above absolute zero, a temperature so cold that the atoms march in lockstep and act as a single "matter wave." Solitons are waves that do not diminish, flatten out or change shape as they move through space. To form solitons, Hulet's team coaxed the BECs into a configuration where the attractive forces between lithium atoms perfectly balance the quantum pressure that tends to spread them out.

The researchers expected to observe the property that a pair of colliding solitons would pass though one another without slowing down or changing shape. However, they found that in certain collisions, the solitons approached one another, maintained a minimum gap between themselves, and then appeared to bounce away from the collision.

Hulet's team specializes in experiments on BECs and other ultracold matter. They use lasers to both trap and cool clouds of lithium gas to temperatures that are so cold that the matter's behavior is dictated by fundamental forces of nature that aren't observable at higher temperatures.

To create solitons, Hulet and postdoctoral research associate Jason Nguyen, the study's lead author, balanced the forces of attraction and repulsion in the BECs.

Cameras captured images of the tiny BECs throughout the process. In the images, two solitons oscillate back and forth like pendulums swinging in opposite directions. Hulet's team, which also included graduate student De Luo and former postdoctoral researcher Paul Dyke, documented thousands of head-on collisions between soliton pairs and noticed a strange gap in some, but not all, of the experiments.

Many of the events that Hulet's team measures occur in one-thousandth of a second or less. To confirm that the "disappearing act" wasn't causing a miniscule interaction between the soliton pairs -- an interaction that might cause them to slowly dissipate over time -- Hulet's team tracked one of the experiments for almost a full second.

The data showed the solitons oscillating back and fourth, winking in and out of view each time they crossed, without any measurable effect.

"This is great example of a case where experiments on ultracold matter can yield a fundamental new insight," Hulet said. "The phase-dependent effects had been seen in optical experiments, but there has been a misunderstanding about the interpretation of those observations." [11]

Photonic molecules

Working with colleagues at the Harvard-MIT Center for Ultracold Atoms, a group led by Harvard Professor of Physics Mikhail Lukin and MIT Professor of Physics Vladan Vuletic have managed to coax photons into binding together to form molecules – a state of matter that, until recently, had been purely theoretical. The work is described in a September 25 paper in Nature.

The discovery, Lukin said, runs contrary to decades of accepted wisdom about the nature of light. Photons have long been described as massless particles which don't interact with each other – shine two laser beams at each other, he said, and they simply pass through one another.

"Photonic molecules," however, behave less like traditional lasers and more like something you might find in science fiction – the light saber.

"Most of the properties of light we know about originate from the fact that photons are massless, and that they do not interact with each other," Lukin said. "What we have done is create a special type of medium in which photons interact with each other so strongly that they begin to act as though they have mass, and they bind together to form molecules. This type of photonic bound state has been discussed theoretically for quite a while, but until now it hadn't been observed. [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) $I = I_0 \sin^2 n\,\varphi/2 \,/\, \sin^2 \varphi/2$

If φ is infinitesimal so that $\sin\varphi = \varphi$ than

(2) $\iota = n^2 \iota_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

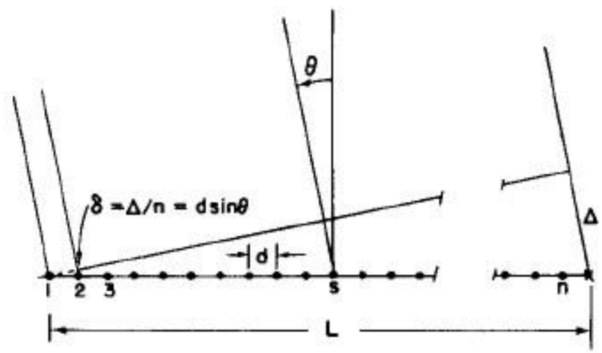


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

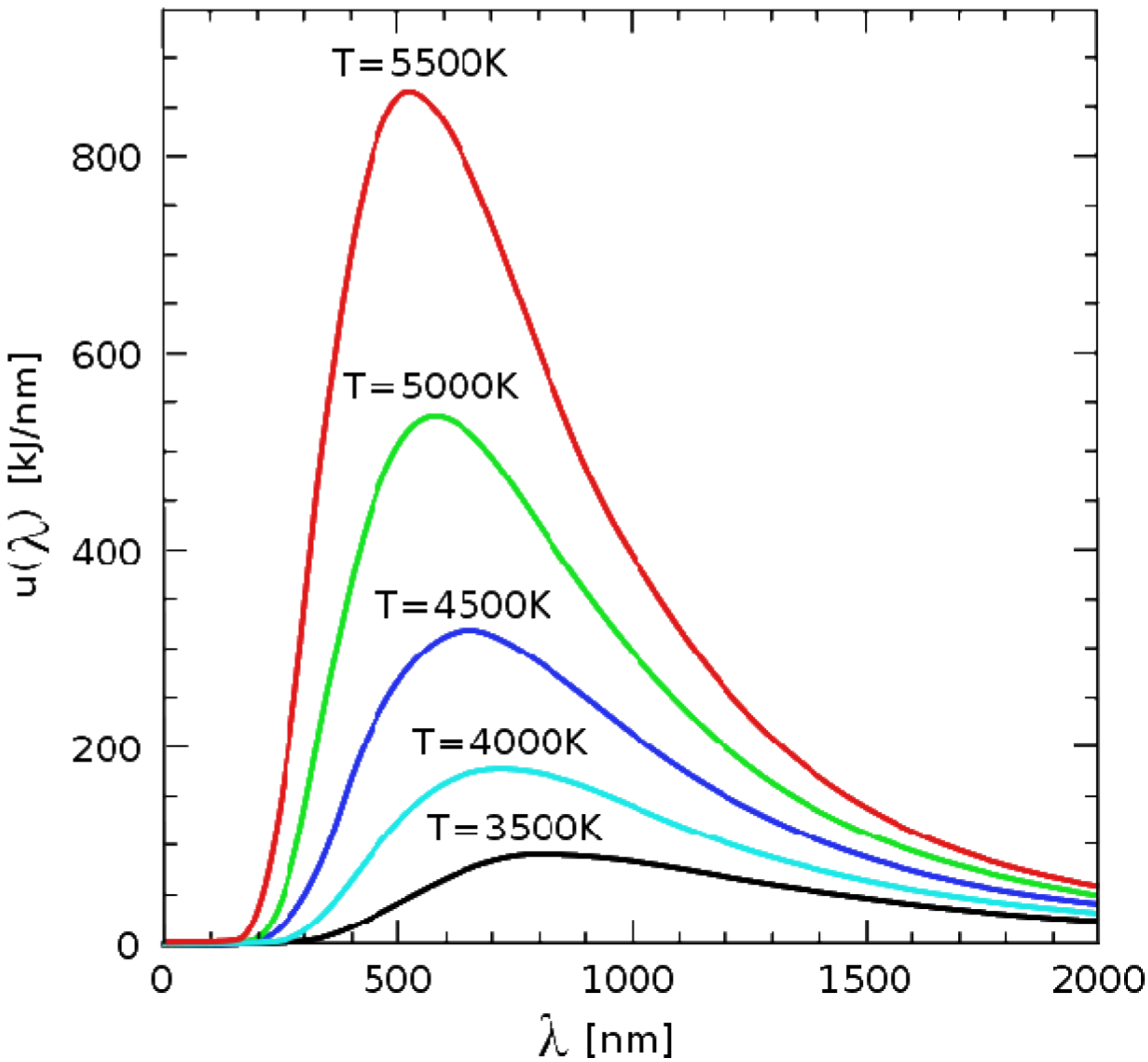


Figure 2. The distribution law for different T temperatures

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 (*v*) 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 $\lambda v = c$, 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

Solitons are localized wave disturbances that propagate without changing shape, a result of a nonlinear interaction that compensates for wave packet dispersion. Individual solitons may collide, but a defining feature is that they pass through one another and emerge from the collision unaltered in shape, amplitude, or velocity, but with a new trajectory reflecting a discontinuous jump. This remarkable property is mathematically a consequence of the underlying integrability of the onedimensional (1D) equations, such as the nonlinear Schrödinger equation, that describe solitons in a variety of wave contexts, including matter waves1, 2. Here we explore the nature of soliton collisions using Bose–Einstein condensates of atoms with attractive interactions confined to a quasi-1D waveguide. Using real-time imaging, we show that a collision between solitons is a complex event that differs markedly depending on the relative phase between the solitons. By controlling the strength of the nonlinearity we shed light on these fundamental features of soliton collisional dynamics, and explore the implications of collisions in the proximity of the crossover between one and three dimensions where the loss of integrability may precipitate catastrophic collapse. [10]

"It's a photonic interaction that's mediated by the atomic interaction," Lukin said. "That makes these two photons behave like a molecule, and when they exit the medium they're much more likely to do so together than as single photons." To build a quantum computer, he explained, researchers need

to build a system that can preserve quantum information, and process it using quantum logic operations. The challenge, however, is that quantum logic requires interactions between individual quanta so that quantum systems can be switched to perform information processing. [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] http://phys.org/news/2013-09-scientists-never-before-seen.html

[10] http://www.nature.com/nphys/journal/vaop/ncurrent/full/nphys3135.html

[11] http://www.sciencedaily.com/releases/2014/11/141102160109.htm

[12] Ultra-cold atoms may wade through quantum friction http://phys.org/news/2016-06-ultra-cold-atoms-wade-quantum-friction.html [13] Study solves 50-year-old puzzle tied to enigmatic, lone wolf waves http://phys.org/news/2016-10-year-old-puzzle-tied-enigmatic-lone.html [14] Scientists develop new method of high-precision optical measurement http://phys.org/news/2016-10-scientists-method-high-precision-optical.html

[15] Inspecting matter using terahertz light https://phys.org/news/2017-08-terahertz.html

[16] ATLAS observes direct evidence of light-by-light scattering

https://phys.org/news/2017-08-atlas-evidence-light-by-light.html

[17] The LEC—now an efficient and bright device

https://phys.org/news/2018-01-lecnow-efficient-bright-device.html

[18] Accelerating light beams in curved space

https://phys.org/news/2018-01-space.html

[19] Compact camera measures light polarization in full

https://physicsworld.com/a/compact-camera-measures-light-polarization-in-full/

[20] Portable polarization-sensitive camera could be used in machine vision, autonomous vehicles, security and more

https://phys.org/news/2019-07-portable-polarization-sensitive-camera-machine-vision.html

[21] Method with polarized light can create and measure nonsymmetrical states in a layered material

https://phys.org/news/2020-02-method-polarized-nonsymmetrical-states-layered.html