Terahertz Skin Cancer Detection

Researchers have developed a new terahertz imaging approach that, for the first time, can acquire micron-scale resolution images while retaining computational approaches designed to speed up image acquisition. This combination could allow terahertz imaging to be useful for detecting early-stage skin cancer without requiring a tissue biopsy from the patient. [19]

A new system developed by UCLA researchers could make it easier and less expensive to diagnose chronic diseases, particularly in remote areas without expensive lab equipment. [18]

University of Illinois researchers have developed a way to produce 3-D images of live embryos in cattle that could help determine embryo viability before in vitro fertilization in humans. [17]

For the first time, the university physicists used extreme ultraviolet radiation (XUV) for this process, which was generated in their own laboratory, and they were thus able to perform the first XUV coherence tomography at laboratory scale. [16]

Energy loss due to scattering from material defects is known to set limits on the performance of nearly all technologies that we employ for communications, timing, and navigation. [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

New terahertz imaging approach could speed up skin cancer detection

Researchers have developed a new terahertz imaging approach that, for the first time, can acquire micron-scale resolution images while retaining computational approaches designed to speed up image acquisition. This combination could allow terahertz imaging to be useful for detecting early-stage skin cancer without requiring a tissue biopsy from the patient.

Terahertz wavelengths fall between microwaves and infrared light on the electromagnetic spectrum. Light in this region is ideal for biological applications because, unlike x-rays, it doesn't carry enough energy to harm tissue. Other research has shown that skin cancer cells absorb terahertz light more strongly than healthy cells, demonstrating that terahertz imaging can be useful for distinguishing between cancerous and healthy tissue.

"Skin cancer can already be detected using terahertz light, but because of the low resolution of current imaging approaches, the cancer can only be seen after it has grown quite large," said the research team's leader, Rayko Stantchev of the University of Exeter, UK. "Ideally, we want to detect the cancer early, when it is still small. We hope that high-resolution terahertz images, combined with the ability to take an image quickly, could eventually lead to a device that could detect cancer in the doctor's office."

In Optica, The Optical Society's journal for high impact research, the researchers showed that their near-field approach to terahertz imaging can achieve a spatial resolution of about nine microns and was compatible with compressed sensing and adaptive imaging algorithms that allow three times faster image acquisition than conventional technologies.

In addition to its practical benefits for medical imaging, the research also represents a new way of accomplishing high resolution terahertz imaging. In conventional imaging, spatial resolution is limited by the diffraction limit, which is determined by the wavelength of light used. Although most imaging techniques detect scattered light at some distance from the object being imaged, the researchers overcame the diffraction limit by using a unique setup to measure close, or near-field, interactions of terahertz waves with the object being imaged. Their approach produced a resolution about 1/45 of the wavelength used for imaging.

"This is the first experimental demonstration, for any spectral region, showing that compressed sensing and adaptive imaging can be performed at resolutions much smaller than the wavelength of light used for imaging," said Stantchev. "Showing that this is physically possible will allow engineers and scientists to start to think about the full potential of this approach."

Subwavelength terahertz imaging

The primary innovation that made the new approach possible was a digital micromirror device (DMD), an array of tiny mirrors that can each be controlled by a computer. The researchers use the DMD to project a pattern of 800nm light onto a silicon wafer, which makes the wafer opaque to terahertz light in areas where the 800nm light hits the silicon. This means that when a terahertz beam passes though the wafer, it creates a patterned terahertz beam on the other side of the wafer that can then interact with an object being imaged. Because the pattern created by the DMD is known, a computer can reconstruct an image of the object based on the detected terahertz light.

Because near-field terahertz imaging approaches are typically plagued by slow acquisition speeds, the researchers designed their approach to be compatible with compressed sensing and adaptive sampling algorithms that increase the rate of imaging. These algorithms work similarly to image compression, which reduces the size of an image by getting rid of any data not needed to visually perceive an image. Compressed sensing and adaptive imaging algorithms take this a step farther by ignoring the unnecessary data to begin with, speeding up imaging by measuring only the vital components of the image.

"We used these algorithms to determine which regions of the wafer are transparent and which regions are not transparent, essentially creating pixels," said Stantchev. "Because we were using a single-pixel terahertz detector, normally each pixel would acquire one measurement. However, by creating many transparent pixels in one measurement, an image can be acquired more quickly by taking fewer measurements than the number of pixels."

The researchers used their setup to image a variety of objects and showed that the method could distinguish arms of a metallic cartwheel that were spaced about nine microns apart.

Moving towards practicality

"For our current setup, we have to use a very intense laser to make the silicon wafers opaque," said Stantchev. "This laser is very big and expensive, so to make this approach practical we needed to figure out how to do it using a much cheaper and smaller laser."

Stantchev is now working with researchers in the Chinese University of Hong Kong who have created a different optical setup that might be able to make the silicon wafers opaque using a less powerful laser. The researchers are now working together to see if this approach might make it possible to acquire subwavelength terahertz images using a laser that cost around $200 instead of the almost $400,000 laser used for the work reported in the Optica paper.

"This is one step toward making the technique more compatible with biological applications," said Stantchev. "Eventually, we envision a device that could be used in the doctor's office that would quickly reveal if skin cancer is present." [19]

Hologram technology could lead to improved diagnoses of chronic diseases in remote areas

A new system developed by UCLA researchers could make it easier and less expensive to diagnose chronic diseases, particularly in remote areas without expensive lab equipment.

The technology uses extremely simple optical hardware and a lens-free microscope, as well as sophisticated algorithms that help reconstruct the images of tissue samples. It could make much-needed diagnostic testing available and affordable for people in developing countries and remote areas that lack the expensive lab equipment currently used to perform tissue biopsies.

The system for making biological samples transparent, also known as "tissue clearing," and then imaging them using a lens-free microscope is described in an article published today in Science Advances, a journal of the American Association for the Advancement of Science. It was developed by a team led by Aydogan Ozcan, the UCLA Chancellor's Professor of Electrical and Computer Engineering and Bioengineering and associate director of the California NanoSystems Institute; and Rajan Kulkarni, an assistant professor of medicine and dermatology at the David Geffen School of Medicine at UCLA, and a member of CNSI.

Tissue biopsy is widely considered the gold standard for detecting diseases like cancer and inflammatory conditions. But the test is relatively expensive and complex, and it requires the use of sophisticated facilities—a serious challenge in regions with limited resources.

In a standard biopsy, tissue is cut into thin slices, around one-tenth of the thickness of a human hair and stained with dyes, so that medical professionals can use a microscope to detect abnormalities and diseased cells. One challenge of that approach—beyond the time and cost involved—is that only a small number of tissue samples can be analyzed at a time.

"Although technological advances have allowed physicians to remotely access medical data to perform diagnoses, there is still an urgent need for a reliable, inexpensive means for disease imaging and identification—particularly in low-resource settings—for pathology, biomedical research and related applications," Ozcan said.

The researchers prepared tissue samples using a technique called Clarity, which makes tissue transparent, or "clears" it, using a chemical process that removes fat and leaves behind proteins and DNA. The method typically requires fluorescent dyes, which can be costly, to stain the tissue samples, but one drawback of those dyes is that the staining tends to degrade over time, making it harder for scientists to gather information from it.

Instead, the UCLA researchers used colored, light-absorbing dyes which, according to Kulkarni, can be used with regular microscopy tools without any noticeable signal loss over time.

And instead of utilizing a machine that's typically used for biopsy testing (a traditional microscope can cost more than $50,000), the UCLA scientists developed a new device made of components that collectively cost just a few hundred dollars: a holographic lens-free microscope that's capable of producing 3-D pictures with one-tenth the image data that conventional scanning optical microscopes need to do the same thing.

The UCLA method also allowed the scientists to use tissue samples that were 0.2 millimeters thick, more than 20 times thicker than a typical sample—a critical benefit of the new system because producing thinner tissue slices is difficult without sophisticated equipment. This also enables scientists to study a larger sample volume, which could help them to detect abnormalities earlier than they otherwise would.

Here's how the test works: First, the cleared tissue is placed in a small container on a silicon chip that contains millions of photo detectors—the same type of chip that's found in mobile phone cameras. When light is shined on the tissue sample, low-resolution shadows from the tissue sample fall on the chip. Those shadows, created by the interference of light scattered by the sample, form holograms of the tissue sample.

Next, the researchers enhance the resolution and enable 3-D imaging by shifting the sample relative to the image sensor and capturing the same holographic shadow, allowing them to digitally view different cross-sections, or digital slices, of the tissue sample.

"Through computation and algorithms, we converted a standard 10-megapixel imager, like those commonly used in mobile phones, into a few-hundred-megapixel microscope that can digitally image through different slices of a thick tissue sample," said Yibo Zhang, the study's first author and a graduate student in Ozcan's lab.

Other members of the research team were Sam Yang, Hongda Wang, Da Teng and Yair Rivenson, all of the Ozcan Research Group; and Yoonjung Shun, Kevin Sung and Harrison Chen of Kulkarni's lab. [18]

New microscope technique reveals internal structure of live embryos

University of Illinois researchers have developed a way to produce 3-D images of live embryos in cattle that could help determine embryo viability before in vitro fertilization in humans.

Infertility can be devastating for those who want children. Many seek treatment, and the cost of a single IVF cycle can be $20,000, making it desirable to succeed in as few attempts as possible. Advanced knowledge regarding the health of embryos could help physicians select those that are most likely to lead to successful pregnancies.

The new method, published in the journal Nature Communications, brought together electrical and computer engineering professor Gabriel Popescu and animal sciences professor Matthew Wheeler in a collaborative project through the Beckman Institute for Advanced Science and Technology at the U. of I.

Called gradient light interference microscopy, the method solves a challenge that other methods have struggled with—imaging thick, multicellular samples.

In many forms of traditional biomedical microscopy, light is shined through very thin slices of tissue to produce an image. Other methods use chemical or physical markers that allow the operator to find the specific object they are looking for within a thick sample, but those markers can be toxic to living tissue, Popescu said.

"When looking at thick samples with other methods, your image becomes washed out due to the light bouncing off of all surfaces in the sample," said graduate student Mikhail Kandel, the co-lead author of the study. "It is like looking into a cloud."

GLIM can probe deep into thick samples by controlling the path length over which light travels through the specimen. The technique allows the researchers to produce images from multiple depths that are then composited into a single 3-D image.

To demonstrate the new method, Popescu's group joined forces with Wheeler and his team to examine cow embryos.

"One of the holy grails of embryology is finding a way to determine which embryos are most viable," Wheeler said. "Having a noninvasive way to correlate to embryo viability is key; before GLIM, we were taking more of an educated guess."

Those educated guesses are made by examining factors like the color of fluids inside the embryonic cells and the timing of development, among others, but there is no universal marker for determining embryo health, Wheeler said.

"This method lets us see the whole picture, like a three-dimensional model of the entire embryo at one time," said Tan Nguyen, the other co-lead author of the study.

Choosing the healthiest embryo is not the end of the story, though. "The ultimate test will be to prove that we have picked a healthy embryo and that it has gone on to develop a live calf," said Marcello Rubessa, a postdoctoral researcher and co-author of the study.

"Illinois has been performing in vitro studies with cows since the 1950s," Wheeler said. "Having the resources made available through Gabriel's research and the other resources at Beckman Institute have worked out to be a perfect-storm scenario."

The team hopes to apply GLIM technology to human fertility research and treatment, as well as a range of different types of tissue research. Popescu plans to continue collaborating with other biomedical researchers and already has had success looking at thick samples of brain tissue in marine life for neuroscience studies. [17]

High-resolution optical coherence tomography without particle accelerator

A visit to the optometrist often involves optical coherence tomography. This imaging process uses infrared radiation to penetrate the layers of the retina and examine it more closely in three dimensions without having to touch the eye at all. This allows eye specialists to diagnose diseases such as glaucoma without any physical intervention. However, this method would have even greater potential for science if a shorter radiation wavelength were used, thus allowing a higher resolution of the image. Physicists at Friedrich Schiller University Jena (Germany) have now achieved just that and they have reported their research findings in the latest issue of the specialist journal Optica.

First XUV coherence tomography at laboratory scale

For the first time, the university physicists used extreme ultraviolet radiation (XUV) for this process, which was generated in their own laboratory, and they were thus able to perform the first XUV coherence tomography at laboratory scale. This radiation has a wavelength of between 20 and 40 nanometres, from which it is therefore just a small step to the X-ray range. "Large-scale equipment, that is to say particle accelerators such as the German Elektronen-Synchotron in Hamburg, are usually necessary for generating XUV radiation," says Silvio Fuchs of the Institute of Optics and Quantum Electronics of the Jena University. "This makes such a research method very complex and costly, and only available to a few researchers."

The physicists from Jena have already demonstrated this method at large research facilities, but they have now applied it at a smaller scale. In this approach, they focus an ultrashort, very intense infrared laser in a noble gas, for example argon or neon. "The electrons in the gas are accelerated by means of an ionisation process," explains Fuchs. "They then emit the XUV radiation." It is true that this method is inefficient, as only a millionth part of the laser radiation is actually transformed from infrared into the extreme ultraviolet range, but this loss can be offset by the use of very powerful laser sources. "It's a simple calculation—the more we put in, the more we get out," adds Fuchs.

Strong image contrasts are produced

The advantage of XUV coherence tomography is that, in addition to the very high resolution, the radiation interacts strongly with the sample, because different substances react differently to light. Some absorb more light and others less. This produces strong contrasts in the images, which provide the researchers with important information, for example regarding the material composition of the object being examined.

"For example, we have created three-dimensional images of silicon chips in a non-destructive way on which we can distinguish the substrate clearly from structures consisting of other materials," says Silvio Fuchs. "If this procedure were applied in biology—for investigating cells, for example, which is one of our aims—it would not be necessary to colour samples, as is normal practice in other high-resolution microscopy methods. Elements such as carbon, oxygen and nitrogen would themselves provide the contrast."

Before that is possible, however, the physicists of the University of Jena still have some work to do. "With the light sources we have at the moment, we can achieve a depth resolution down to 24 nanometres. Although this is sufficient for producing images of small structures, for example in semiconductors, the structure sizes of current chips are in some cases already smaller. However, with new, even more powerful lasers, it should be possible in future to achieve a depth resolution of as little as three nanometres with this method," notes Fuchs. "We have shown in principle that it is possible to use this method at laboratory scale."

The long-term aim is to develop a cost-effective and user-friendly device combining the laser with the microscope, which would enable the semiconductor industry or biological laboratories to use this imaging technique with ease. [16]

New technique to suppress sound waves from disorder to improve optical fiber communication

Energy loss due to scattering from material defects is known to set limits on the performance of nearly all technologies that we employ for communications, timing, and navigation. In micro-mechanical gyroscopes and accelerometers, such as those commonly found in cellphones today, microstructural disorder impacts measurement drift and overall accuracy of the sensor, analogous to how a dirty violin string might impact one's enjoyment of beautiful music. In optical fiber communication systems, scattering from material defects can reduce data fidelity over long distances thereby reducing achievable bandwidth. Since defect-free materials cannot be obtained, how can we possibly improve on the fundamental technological limits imposed by disorder?

A research collaboration between the University of Illinois at Urbana-Champaign, the National Institute of Standards and Technology, and the University of Maryland has revealed a new technique by which scattering of sound waves from disorder in a material can be suppressed on demand. All of this, can be simply achieved by illuminating with the appropriate color of laser light. The result, which is published in Nature Communications, could have a wide-ranging impact on sensors and communication systems.

Gaurav Bahl, an assistant professor of mechanical science and engineering, and his research team have been studying the interaction of light with sound in solid state micro-resonators. This new result is the culmination of a series of experiments pursued by his team over the past several years, and a new scientific question posed in the right place.

"Resonators can be thought of as echo chambers for sound and light, and can be as simple as micro-spherical balls of glass like those we used in our study," Bahl explained. "Our research community has long understood that light can be used to create and amplify sound waves in resonators through a variety of optical forces. The resonant echoes help to increase the interaction time between sound, light, and material disorder, making these subtle effects much easier to observe and control. Since interactions within resonators are fundamentally no different from those taking place in any other system, these can be a really compact platform for exploring the underlying physics."

The key to suppressing scattering from disorder is to induce a mismatch in the propagation between the original and scattered directions. This idea is similar to how an electric current prefers to flow along the path of least resistance, or how water prefers to flow through a wider pipe rather than a constricted one. To suppress back-scattering of forward-moving sound waves, one must create a large acoustic impedance in the backward direction. This asymmetry for forward and backward propagating waves is termed as chirality of the medium. Most solid-state systems do not have chiral properties, but these properties can be induced through magnetic fields or through space-time variation of the medium.

"A few years ago, we discovered that chirality can be induced for light using an opto-mechanical phenomenon, in which light couples with propagating sound waves and renders the medium transparent. Our experiments at that time showed that the induced optical transparency only allows light to move unidirectionally, that is, it creates a preferentially low optical impedance in one direction," Bahl said. "It is then that we met our collaborator Jacob Taylor, a physicist at NIST, who asked us a simple question. What happens to the sound waves in such a system?"

"Our theoretical modeling predicted that having a chiral system for sound propagation could suppress any back-scattering that may have been induced by disorder," explained Taylor. "This concept arose from work we've been doing in the past few years investigating topological protection for light, where chiral propagation is a key feature for improving the performance of devices. Initially the plan with Bahl's team was just to show a difference between the forward and backward propagating sound waves, using a cooling effect created by light. But the system surprised us with an even stronger practical effect than expected."

That simple question launched a new multi-year research effort in a direction that has not been explored previously. Working in close collaboration, the team discovered that Brillouin light scattering, a specific kind of opto-mechanical interaction, could also induce chirality for sound waves. Between the experimental tools in Bahl's lab, and the theoretical advancements in Taylor's lab, the pieces of the puzzle were already in place.

"We experimentally prepared a chiral optomechanical system by circulating a laser field in the clockwise direction in a silica glass resonator. The laser wavelength, or color, was specially arranged to induce optical damping of only clockwise sound waves. This created a large acoustic impedance mismatch between clockwise and counter-clockwise directions of propagation," explained Seunghwi Kim, first author of the study. "Sound waves that were propagating the clockwise direction experienced very high losses due to the opto-mechanical cooling effect. Sound waves moving in the counter-clockwise direction could move freely. Surprisingly, we saw a huge reduction of scattering loss for counter-clockwise sound waves, since those waves could no longer scatter into the clockwise direction! In other words, even though disorder was present in the resonator, its action was suppressed."

Just as sound is the primary method of voice communication between humans, electromagnetic waves like radio and light are the primary technology used for global communications. What could this discovery mean for the communications industry? Disorder and material defects are unavoidable optical fiber systems, resulting in lower data fidelity, bit errors, and bandwidth limitations. The team believes that technologies based on this discovery could be leveraged to circumvent the impact of unavoidable material defects in such systems.

"We've seen already that many sensors, such as those found in your phone or in your car, can be limited by intrinsic defects in the materials," added Taylor. "The approach introduced here provides a simple means of circumventing those challenges, and may even help us approach the limits set by quantum mechanics, rather than our own engineering challenges."

Practical applications of this result may not be too many years off. Reduction of mechanical losses could also directly improve mechanics-based inertial navigation sensors that we use today. Examples that we encounter in daily life are accelerometers and gyroscopes, without which our mobile phones would be a lot less capable, and our cars and airplanes a lot less safe. [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 (MgF2); the second one out of silicon nitride (Si3N4).

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 multi-soliton 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) $I = I_0 \sin^2 n\ \phi/2\ /\ \sin^2 \phi/2$

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

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

This gives us the idea of

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

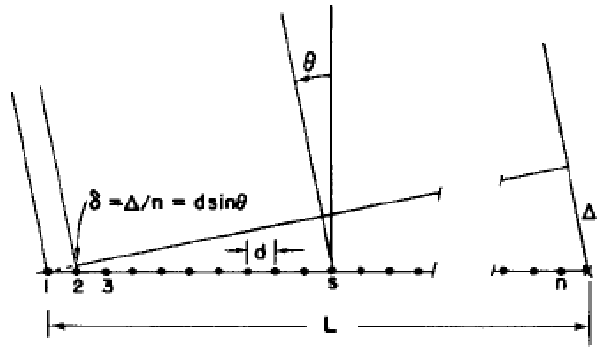

Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

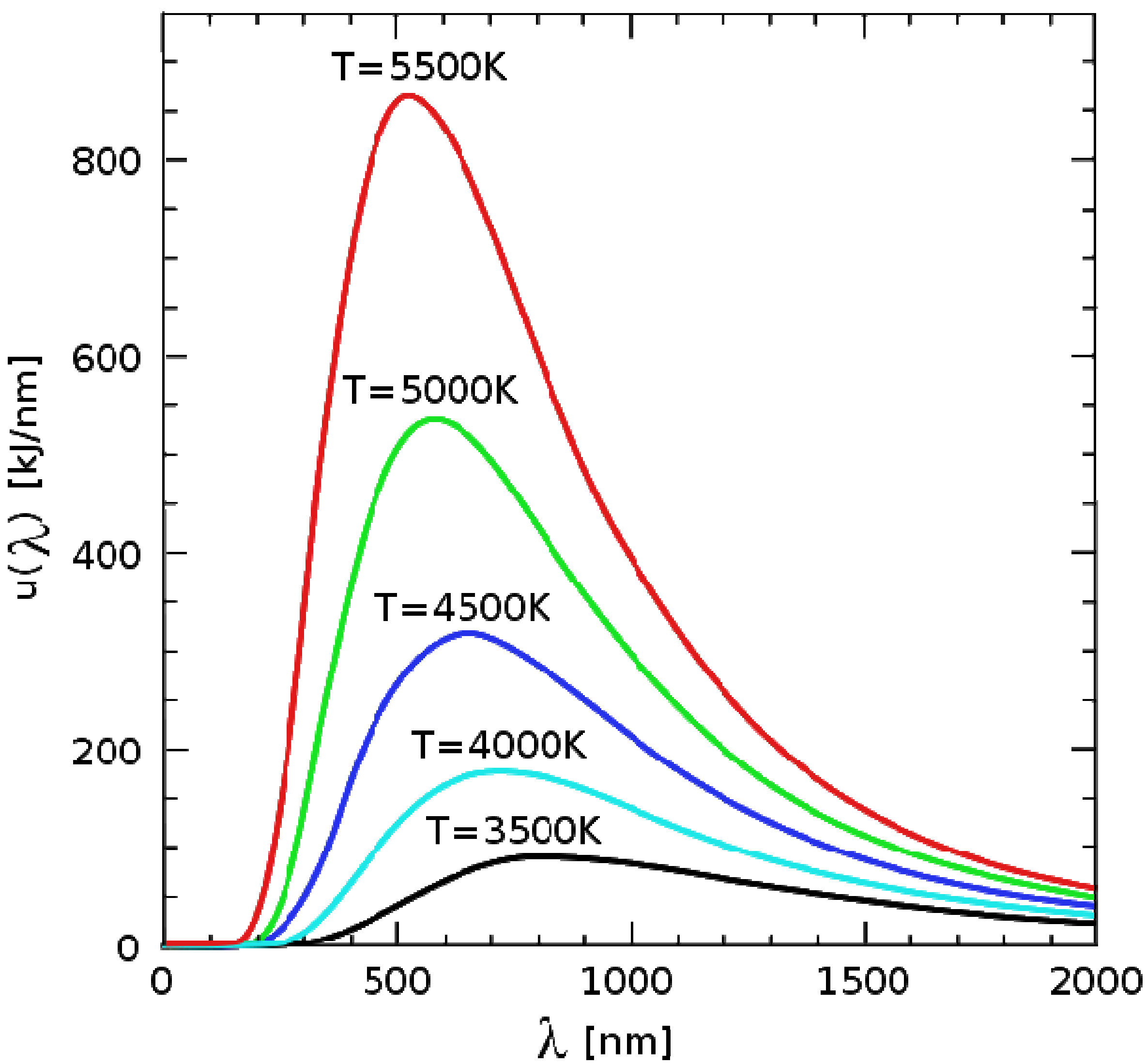

Figure 2. The distribution law for different T temperatures

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

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 one-dimensional (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] New technique to suppress sound waves from disorder to improve optical fiber communication

https://phys.org/news/2017-08-technique-suppress-disorder-optical-fiber.html

[16] High-resolution optical coherence tomography without particle accelerator

https://phys.org/news/2017-08-high-resolution-optical-coherence-tomography-particle.html

[17] New microscope technique reveals internal structure of live embryos

https://phys.org/news/2017-08-microscope-technique-reveals-internal-embryos.html

[18] Hologram technology could lead to improved diagnoses of chronic diseases in remote areas

https://phys.org/news/2017-08-hologram-technology-chronic-diseases-remote.html

[19] New terahertz imaging approach could speed up skin cancer detection

https://phys.org/news/2017-08-terahertz-imaging-approach-skin-cancer.html