Dance of Electrons in Space

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A surprising new class of X-ray pulsating variable stars has been discovered by a team of American and Canadian astronomers led by Villanova University's Scott Engle and Edward Guinan. [15]

Late last year, an international team including researchers from the Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University announced the discovery of more than 60 extremely distant quasars, nearly doubling the number known to science - and thus providing dozens of new opportunities to look deep into our universe's history. [14]

Fuzzy pulsars orbiting black holes could unmask quantum gravity. [13]

Cosmologists trying to understand how to unite the two pillars of modern science – quantum physics and gravity – have found a new way to make robust predictions about the effect of quantum fluctuations on primordial density waves, ripples in the fabric of space and time. [12]

Physicists have performed a test designed to investigate the effects of the expansion of the universe—hoping to answer questions such as "does the expansion of the universe affect laboratory experiments?", "might this expansion change the lengths of solid objects and the time measured by atomic clocks differently, in violation of Einstein's equivalence principle?", and "does spacetime have a foam-like structure that slightly changes the speed of photons over time?", an idea that could shed light on the connection between general relativity and quantum gravity. [11]

Einstein's equivalence principle states that an object in gravitational free fall is physically equivalent to an object that is accelerating with the same amount of force in the absence of gravity. This principle lies at the heart of general relativity and has been experimentally tested many times. Now in a new paper, scientists have experimentally demonstrated a conceptually new way to test *the equivalence principle that could detect the effects of a relatively new concept called spin-gravity coupling. [10]*

A recent peer-reviewed paper by physicist James Franson from the University of Maryland in the US has initiated a stir among physics community. Issued in the New Journal of Physics, the paper points to evidence proposing that the speed of light as defined by the theory of general relativity, is slower than originally thought. [9]

Gravitational time dilation causes decoherence of composite quantum systems. Even if gravitons are there, it's probable that we would never be able to perceive them. Perhaps, assuming they continue inside a robust model of quantum gravity, there may be secondary ways of proving their actuality. [7]

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 accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.

The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.

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 diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the relativistic quantum theory.

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Author: George Rajna

Preface

Physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena. In a new proposed experiment in this area, two toaster-sized "nanosatellites" carrying entangled condensates orbit around the Earth, until one of them moves to a different orbit with different gravitational field strength. As a result of the change in gravity, the entanglement between the condensates is predicted to degrade by up to 20%. Experimentally testing the proposal may be possible in the near future. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

NASA mission uncovers a dance of electrons in space

You can't see them, but swarms of electrons are buzzing through the magnetic environment—the magnetosphere—around Earth. The electrons spiral and dive around the planet in a complex dance dictated by the magnetic and electric fields. When they penetrate into the magnetosphere close enough to Earth, the high-energy electrons can damage satellites in orbit and trigger auroras. Scientists with NASA's Magnetospheric Multiscale, or MMS, mission study the electrons' dynamics to better understand their behavior. A new study, published in Journal of Geophysical Research revealed a bizarre new type of motion exhibited by these electrons.

Electrons in a strong magnetic field usually exhibit a simple behavior: They spin tight spirals along the magnetic field. In a weaker field region, where the direction of the magnetic field reverses, the electrons go free style—bouncing and wagging back and forth in a type of movement called Speiser motion. New MMS results show for the first time what happens in an intermediate strength field. Then these electrons dance a hybrid, meandering motion—spiraling and bouncing about before being ejected from the region. This motion takes away some of the field's energy and it plays a key role in magnetic reconnection, a dynamic process, which can explosively release large amounts of stored magnetic energy.

"MMS is showing us the fascinating reality of magnetic reconnection happening out there," said Li-Jen Chen, lead author of the study and MMS scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

As MMS flew around Earth, it passed through an area of a moderate strength magnetic field where electric currents run in the same direction as the magnetic field. Such areas are known as intermediate guide fields. While inside the region, the instruments recorded a curious interaction of electrons with the current sheet, the thin layer through which the current travels. As the incoming particles encountered the region, they started gyrating in spirals along the guide field, like they do in a strong magnetic field, but in larger spirals. The MMS observations also saw signatures of the particles gaining energy from the electric field. Before long, the accelerated particles escaped the current sheet, forming high-speed jets. In the process, they took away some of the field's energy, causing it to gradually weaken.

The magnetic field environment where the electrons' motions were observed was uniquely created by magnetic reconnection, which caused the current sheet to be tightly confined by bunched-up magnetic fields. The new results help the scientists better understand the role of electrons in reconnection and how magnetic fields lose energy.

MMS measures the electric and magnetic fields it flies through, and counts electrons and ions to measure their energies and directions of motion. With four spacecraft flying in a compact, pyramid formation, MMS is able to see the fields and particles in three dimensions and look at small-scale particle dynamics, in a way never before achieved.

"The time resolution of MMS is one hundred times faster than previous missions," said Tom Moore, senior project scientist for MMS at NASA's Goddard Space Flight Center. "That means we can finally see what's going on in such narrow layers and will be able to better predict how fast reconnection occurs in various circumstances."

Understanding the speed of reconnection is essential for predicting the intensity of the explosive energy release. Reconnection is an important energy release process across the universe and is thought to be responsible for some shock waves and cosmic rays. Solar flares on the sun, which can trigger space weather, are also caused by magnetic reconnection.

With two years under its belt, MMS has been revealing new and surprising phenomena near Earth. These discoveries enable us to better understand Earth's dynamic space environment and how it affects our satellites and technology.

MMS is now heading to a new orbit which will take it through magnetic reconnection areas on the side of Earth farther from the sun. In this region, the guide field is typically weaker, so MMS may see more of these types of electron dynamics. [18]

NASA observations reshape basic plasma wave physics

When NASA's Magnetospheric Multiscale—or MMS—mission was launched, the scientists knew it would answer questions fundamental to the nature of our universe—and MMS hasn't disappointed. A new finding, presented in a paper in Nature Communications, provides observational proof of a 50-year-old theory and reshapes the basic understanding of a type of wave in space known as a kinetic Alfvén wave. The results, which reveal unexpected, small-scale complexities in the wave, are also applicable to nuclear fusion techniques, which rely on minimizing the existence of such waves inside the equipment to trap heat efficiently.

Kinetic Alfvén waves have long been suspected to be energy transporters in plasmas—a fundamental state of matter composed of charged particles—throughout the universe. But it wasn't until now, with the help of MMS, that scientists have been able to take a closer look at the microphysics of the waves on the relatively small scales where the energy transfer actually happens.

"This is the first time we've been able to see this energy transfer directly," said Dan Gershman, lead author and MMS scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the University of Maryland in College Park. "We're seeing a more detailed picture of Alfvén waves than anyone's been able to get before."

The waves could be studied on a small scale for the first time because of the unique design of the MMS spacecraft. MMS's four spacecraft fly in a compact 3-D pyramid formation, with just four miles between them—closer than ever achieved before and small enough to fit between two wave peaks. Having multiple spacecraft allowed the scientists to measure precise details about the wave, such as how fast it moved and in what direction it travelled.

Previous multi-spacecraft missions flew at much larger separations, which didn't allow them to see the small scales—much like trying to measure the thickness of a piece of paper with a yardstick. MMS's tight flying formation, however, allowed the spacecraft to investigate the shorter wavelengths of kinetic Alfvén waves, instead of glossing over the small-scale effects.

"It's only at these small scales that the waves are able to transfer energy, which is why it's so important to study them," Gershman said.

As kinetic Alfvén waves move through a plasma, electrons traveling at the right speed get trapped in the weak spots of the wave's magnetic field. Because the field is stronger on either side of such spots, the electrons bounce back and forth as if bordered by two walls, in what is known as a magnetic mirror in the wave. As a result, the electrons aren't distributed evenly throughout: Some areas have a higher density of electrons, and other pockets are left with fewer electrons. Other electrons, which travel too fast or too slow to ride the wave, end up passing energy back and forth with the wave as they jockey to keep up.

The wave's ability to trap particles was predicted more than 50 years ago but hadn't been directly captured with such comprehensive measurements until now. The new results also showed a much higher rate of trapping than expected.

This method of trapping particles also has applications in nuclear fusion technology. Nuclear reactors use magnetic fields to confine plasma in order to extract energy. Current methods are highly inefficient as they require large amounts of energy to power the magnetic field and keep the plasma hot. The new results may offer a better understanding of one process that transports energy through a plasma.

"We can produce, with some effort, these waves in the laboratory to study, but the wave is much smaller than it is in space," said Stewart Prager, plasma scientist at the Princeton Plasma Physics Laboratory in Princeton, New Jersey. "In space, they can measure finer properties that are hard to measure in the laboratory."

This work may also teach us more about our sun. Some scientists think kinetic Alfvén waves are key to how the solar wind—the constant outpouring of solar particles that sweeps out into space—is heated to extreme temperatures. The new results provide insight on how that process might work.

Throughout the universe, kinetic Alfvén waves are ubiquitous across magnetic environments, and are even expected to be in the extra-galactic jets of quasars. By studying our near-Earth environment, NASA missions like MMS can make use of a unique, nearby laboratory to understand the physics of magnetic fields across the universe. [17]

Physicists reveal experimental verification of a key source of fast reconnection of magnetic fields

Magnetic reconnection, a universal process that triggers solar flares and northern lights and can disrupt cell phone service and fusion experiments, occurs much faster than theory says that it should. Now researchers at the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) and Germany's Max Planck Institute of Plasma Physics have discovered a source of the speed-up in a common form of reconnection. Their findings could lead to more accurate predictions of damaging space weather and improved fusion experiments.

Reconnection occurs when the magnetic field lines in plasma—the collection of atoms and charged electrons and atomic nuclei, or ions, that make up 99 percent of the visible universe—converge and forcefully snap apart. Electrons that exert a varying degree of pressure form an important part of this process as reconnection takes place.

The research team found that variation in the electron pressure develops along the magnetic field lines in the region undergoing reconnection. This variation balances and keeps a strong electric current inside the plasma from growing out of control and halting the reconnection process. It is this balancing act that makes possible fast reconnection.

"The main issue we addressed is how reconnection can take place so quickly," said Will Fox, lead author of a paper that detailed the findings in March in the journal Physical Review Letters. "Here we've shown experimentally how electron pressure accelerates the process."

The physics team built a picture of the gradient and other parameters of reconnection from research conducted on the Magnetic Reconnection Experiment (MRX) at PPPL, the leading laboratory device for studying reconnection. The findings marked the first experimental confirmation of predictions made by earlier simulations performed by other researchers of the behavior of ions and electrons during reconnection. "The experiments demonstrate how the plasma can sustain a large electric field while preventing a large electric current from building up and halting the reconnection process," said Fox.

Among potential applications of the results:

Predictions of space storms. Magnetic reconnection in the magnetosphere, the magnetic field that surrounds the Earth, can set off geomagnetic "substorms" that disable communications and global positioning satellites (GPS) and disrupt electrical grids. Improved understanding of fast reconnection can help locate regions where the process triggering storms is ready to take place.

Mitigation of the impact. Advanced warning of reconnection and the disruptions that may follow can lead to steps to protect sensitive satellite systems and electric grids.

Improvement of fusion facility performance. The process observed in MRX likely plays a key role in producing what are called "sawtooth" instabilities that can halt fusion reactions. Understanding the process could open the door to controlling it and limiting such instabilities. "How sawtooth happens so fast has been a mystery that this research helps to explain," said Fox. "In fact, it was computer simulations of sawtooth crashes that first linked electron pressure to the source of fast reconnection." [16]

The surprising discovery of a new class of pulsating X-ray stars

A surprising new class of X-ray pulsating variable stars has been discovered by a team of American and Canadian astronomers led by Villanova University's Scott Engle and Edward Guinan. Part of the Villanova Secret Lives of Cepheids program, the new X-ray observations, obtained by NASA's Chandra X-ray Observatory and published Thursday, March 23rd in the Astrophysical Journal, reveal that the bright prototype of Classical Cepheids, d Cephei, is a periodic pulsed X-ray source.

Research team members sharing in the discovery included Graham Harper, University of Colorado; Nancy Remage Evans, Harvard Center for Astrophysics; Manfred Cuntz, University of Texas, Arlington; and Hilding Neilson, University of Toronto.

The prototype star after which all Cepheids are named, d Cephei (d Cep) is, at a distance of 890 light years away, also one of the closest of its type. Cepheids are a famous class of pulsating variable stars and among the most astronomically important objects in the Universe. By measuring the pulsation periods and brightness of Cepheids astrophysicists can measure distances to other galaxies and calibrate the extragalactic distance scale. Cepheids also play an increasingly vital role in the effort to precisely measure the expansion rate of the Universe and to resolve the developing Hubble discrepancy.

Data recently returned for d Cep from the Chandra X-ray Observatory, combined with previous X-ray measures secured with the XMM-Newton X-ray satellite, have shown that d Cep has X-ray variations occurring in accord with the supergiant star's 5.4 day pulsation period. X-rays are observed at all phases of the star's pulsations, but sharply rise by ~400% near the times when the star swells to its maximum diameter of about 45 times that of the Sun.

"Our first X-ray observations of Cepheids were made in 2006, and our first detections were met with a good bit of skepticism. The notion that Cepheids could be X-ray active seemed far-fetched because these stars are only a few times more massive and a little hotter than the Sun," said Engle. "Over a decade later, we've finally shown that they can in fact be X-ray variable, but the work is far from over. Now we need to understand just how they generate and modulate their X-ray emissions, and what effect this could have on the Leavitt Period-Luminosity Law."

d Cep is a bright star, easily seen without a telescope to the North in the constellation Cepheus. This yellow supergiant star, whose optical brightness variations were discovered in 1784, was one of the first variable stars known. Its light variations are the result of radial pulsations, in which the star contracts and expands with the same 5.4 day period as its brightness variations. The surface of d Cep reaches supersonic speeds of about 82,000 miles per hour, while the star shrinks and grows by roughly 2 million miles during each pulsation period. Thousands of Cepheids have been found in our galaxy as well as in other galaxies hundreds of millions of light years away.

Analyses of the X-ray data indicate the unexpected presence of very hot plasmas in d Cep, with temperatures above 10 million degrees Celsius. It is not certain yet whether the X-rays arise from pulsation-induced shock waves in the star's dynamic atmosphere, or from the generation of a stellar magnetic field that becomes tangled, emitting X-rays. Other Cepheids are being studied to understand the source of the heated, X-ray emitting plasmas. At least two additional Cepheids show potential X-ray variability.

The research team led by Engle and Guinan previously used the Hubble Space Telescope to study ultraviolet emission lines from d Cep and other Cepheids. These emission lines originate in plasmas of up to 300,000 degrees Celsius; cooler than X-ray emitting plasmas but still far hotter than the surfaces of the stars. The ultraviolet emissions also vary in accord with the Cepheids' pulsation periods but sharply rise after the Cepheid reaches minimum radius, as opposed to the X-ray emissions which peak just after maximum radius. The team is still studying exactly why the ultraviolet and X-ray emissions peak at such different phases of the star's pulsations.

"Classical Cepheid stars are considered to be the most important variable stars in the sky. These pulsating supergiant stars have been used since the mid-1920s by Edwin Hubble and other astronomers to measure the distances to galaxies and determine the expansion rate of the universe," said Guinan. "After many tries, the failure to detect X-rays from Cepheids during the 1980-90s led astronomers to give up on them as potential X-ray stars. So it was a big (but pleasant) surprise to find X-ray emission from d Cep and several other Cepheids."

This discovery of X-rays for d Cep and some other Cepheids is the newest in a list of recently discovered Cepheid properties. These include circumstellar gas and dusty environments, infrared excesses, ultraviolet emission lines, and cycle-to-cycle variations in the stars' periodic light changes. This combination of discoveries shows that Cepheids, after more than two centuries of study, still have their secrets. Given the astrophysical and cosmological importance of Cepheids, and the high precisions required to test cosmological models, these new discoveries should be better understood. X-ray observations of other bright Cepheids are planned to unravel their X-ray behavior. [15]

Why the discovery of a bevy of quasars will boost efforts to understand galaxies' origins

Late last year, an international team including researchers from the Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University announced the discovery of more than 60 extremely distant quasars, nearly doubling the number known to science - and thus providing dozens of new opportunities to look deep into our universe's history.

Now, in a roundtable discussion hosted by The Kavli Foundation, three astrophysicists, including a member of the team that made the discovery, explain why this important finding will help unravel the secrets of our modern universe's origins, as well as the mysterious connection between galaxies and monstrous black holes.

Quasars are the stupendously bright regions in the cores of galaxies, powered by gargantuan black holes.

"You can think of quasars as lighthouses in the dark of the early universe," said Roberto Maiolino, a professor of experimental astrophysics at the Cavendish Laboratory of the University of Cambridge and director of the Kavli Institute for Cosmology, Cambridge (KICC). "Just as a lighthouse's beam might shine on nearby land forms, making them visible from far away, quasars enable us to investigate the very distant universe and understand the physics of primordial galaxies."

Ultra-distant quasars offer a unique window into how both galaxies and supermassive black holes developed and interacted. But they are rare, so finding them requires extensive observing surveys using powerful, large telescopes that take images across a large part of the sky.

"My colleagues and I used both the Sloan Digital Sky Survey and the Pan-STARRS survey to find the quasars that we recently reported. Before those surveys began, we really knew very little about distant quasars," said Linhua Jiang, the Youth Qianren Research Professor at the KIAA and an author on two studies published in November and December in The Astrophysical Journal about the newfound quasars.

Jiang also noted how the new haul of distant quasars will help show the regions where matter was densest in the early cosmos. Those over-dense regions are where the great clusters of galaxies we see today had their origins. "We'll learn more about the early history of galaxies and how the cosmos got its shape, so to speak," he said.

Studying these quasars will also deepen our understanding of why nearly all galaxies have supermassive black holes at their cores, begging the chicken-or-the-egg question of which came first, the galaxies themselves or the black holes, or whether the two arose interrelatedly.

"Knowing more about the black holes powering quasars will allow us to know more about how galaxies develop," said Marta Volonteri, the research director at the Observatory of Paris and the principal investigator of the BLACK project, which investigates how supermassive black holes influenced their host galaxies, especially as quasars, in the early universe. "And knowing about the evolution of galaxies allows us to trace the universe's history overall. That's why finding more quasars to study is so fundamental." [14]

Fuzzy pulsars orbiting black holes could unmask quantum gravity

WANT to get to the bottom of one of the biggest mysteries in science? The best way might be to catch sight of a fast-spinning stellar corpse.

General relativity, which describes massive objects like black holes, and quantum mechanics, which governs subatomic particles, are tremendously successful in their own realms. But no one has yet come up with a way to unite them.

A theory of quantum gravity is one of the most sought after in physics (see “The string-loop theory that might finally untangle the universe“). Several candidates exist, but current Earth-based experiments can’t test them directly. Now, Michael Kavic at Long Island University in New York and his colleagues have devised a cosmic test. Their apparatus: a binary system made up of a black hole and a pulsar.

Only tens of kilometres across, a pulsar forms when a star at least eight times the mass of the sun runs out of nuclear fuel and explodes as a supernova. What remains is a rotating object that also emits beams of radio waves from its magnetic poles.

Those poles seldom coincide with its rotational axis, meaning a suitably placed observer will see the radio signal “flashing” past with near-perfect regularity, like a lighthouse beam. This eerie repetition meant that when pulsars were discovered in the 1960s, they were thought to be alien beacons. That regularity also makes them good quantum gravity probes, says Kavic.

“If they do observe something, that would be big. It would be a whole new field of study”

Some theories, like one proposed by Steven Giddings at the University of California, Santa Barbara, in 2014, predict that the black hole’s internal state can be linked to quantum fields outside, in the black hole’s “atmosphere”. This coupling would show up as fluctuations in the space-time around the black hole.

If a pulsar is orbiting it, its radio signal will look normal whenever the pulsar passes in front of the black hole. But when the black hole eclipses the pulsar, the radio beam will reach us via a region of space-time that is steeply curved by the immense gravity.

General relativity predicts that as a result, the signal will arrive early or late at our radio telescopes, with the discrepancy altering smoothly as the pulsar orbits. Quantum gravity, however, says the fluctuating space-time will alter the signal in irregular ways – such that a graph of the arrival times will look “fuzzy”.

Studying a fuzzy pulsar could confirm Giddings’s version of quantum gravity. Kavic and his colleagues propose searching for pulsar-black hole pairs using planned instruments such as the Square Kilometre Array and the Event Horizon Telescope (arxiv.org/abs/1607.00018v3).

Crucially, this type of measurement has been done before: astronomers have examined pulsars in binary systems with neutron stars, which are stellar corpses that don’t emit a lighthouse-like radio beam. “We know how to do this,” Kavic says.

Those observations failed to detect any departures from general relativity. But black holes are more massive than neutron stars, so warp space-time more dramatically and could show a measurable effect.

Some theorists are sceptical. Samir Mathur at Ohio State University in Columbus says the test might just not work. The quantum effects would need to extend far enough outside the event horizon – the surface inside of which matter can’t escape the black hole – to affect those pulsar beams that skirt the black hole. Even Giddings says there’s some luck involved in finding a binary that fits the bill.

That said, Mathur feels the idea is a good one. “If they do observe something, that would be big,” he says. “It would be a whole new field of study.”

This article appeared in print under the headline “Fuzzy pulsars could help unmask quantum gravity” [13]

Cosmologists a step closer to understanding quantum gravity

Cosmologists trying to understand how to unite the two pillars of modern science – quantum physics and gravity – have found a new way to make robust predictions about the effect of quantum fluctuations on primordial density waves, ripples in the fabric of space and time.

Researchers from the University of Portsmouth have revealed quantum imprints left on cosmological structures in the very early Universe and shed light on what we may expect from a full quantum theory of gravity.

Dr Vincent Vennin, from the Institute of Cosmology and Gravitation said: "We haven't solved quantum gravity but we've learnt a little more about how it would work.

"Physicists do not yet know how to combine theories of gravity and the quantum world. Yet both play a crucial role in the very early Universe where the expansion of space is driven by gravity and cosmological structures that arise from quantum fluctuations.

"Quantum fluctuations during inflation are thought to be the origin of all structure in the Universe. Structures we see today such as galaxies, stars, planets and people can be traced back to these primordial fluctuations."

The paper is co-authored by Professor David Wands and Dr Hooshyar Assadullahi. It was published today in the Physical Review Letters. [12]

Cryogenic test probes Einstein's equivalence principle, general relativity, and spacetime 'foam'

Physicists have performed a test designed to investigate the effects of the expansion of the universe—hoping to answer questions such as "does the expansion of the universe affect laboratory experiments?", "might this expansion change the lengths of solid objects and the time measured by atomic clocks differently, in violation of Einstein's equivalence principle?", and "does spacetime have a foam-like structure that slightly changes the speed of photons over time?", an idea that could shed light on the connection between general relativity and quantum gravity.

In their study published in Physical Review Letters, E. Wiens, A.Yu. Nevsky, and S. Schiller at Heinrich Heine Universität Düsseldorf in Germany have used a cryogenic resonator to make some of the most precise measurements yet on the length stability of a solid object. Overall, the results provide further confirmation of Einstein's equivalence principle, which is the foundation on which the theory of general relativity is based on. And in agreement with previous experiments, the researchers found no evidence of spacetime foam.

"It is not easy to imagine ways of testing for consequences of the expansion of the universe that occur in the laboratory (as opposed to studying distant galaxies)," Schiller told Phys.org. "Our approach is one way to perform such a test. That we have not observed any effect is consistent with the prediction of general relativity."

Over the course of five months, the researchers made daily measurements of the resonator's length by measuring the frequency of an electromagnetic wave trapped within it. In order to suppress all thermal motion, the researchers operated the resonator at cryogenic temperature (1.5 degrees above absolute zero). In addition, external disturbances, such as tilt, irradiation by laser light, and some other effects that might destabilize the device were kept as small as possible.

To measure the resonator's frequency, the researchers used an atomic clock. Any change in frequency would indicate that the change in length of the resonator differs from the change in time measured by the atomic clock.

The experiment detected virtually no change in frequency, or "zero drift"—more precisely, the mean fractional drift was measured to be about 10-20/second, corresponding to a decrease in length that the researchers describe as equivalent to depositing no more than one layer of molecules onto the mirrors of the resonator over a period of 3000 years. This drift is the smallest value measured so far for any resonator.

One of the most important implications of the null result is that it provides further support for the equivalence principle. Formulated by Einstein in the early 1900s, the equivalence principle is the idea that gravity and acceleration—such as the acceleration a person would feel in an upward-accelerating elevator in space—are equivalent.

This principle leads to several related concepts, one of which is local position invariance, which states that the non-gravitational laws of physics (for example, electromagnetism) are the same everywhere. In the current experiment, any amount of resonance drift would have violated local position invariance. Along similar lines, any amount of resonance drift would also have violated general relativity, since general relativity prohibits changes to the length of solid objects caused by the expansion of the universe.

Finally, the experiment also attempted to detect the hypothetical existence of spacetime foam. One of the effects of spacetime foam would be that repeated measurements of a length would produce fluctuating results. The constant measurement results reported here therefore indicate that such fluctuations, if they exist at all, must be very small.

In the future, the researchers hope that the extremely precise measurement technique using the cryogenic resonator could be used for other applications.

"One of the greatest outcomes of this work is that we have developed an approach to make and operate an optical resonator that has extremely little drift," Schiller said. "This could have applications to the field of atomic clocks and precision measurements—for example, for the radar tracking of spacecraft in deep space." [11]

Test of equivalence principle searches for effects of spin-gravity coupling

Einstein's equivalence principle states that an object in gravitational free fall is physically equivalent to an object that is accelerating with the same amount of force in the absence of gravity. This principle lies at the heart of general relativity and has been experimentally tested many times. Now in a new paper, scientists have experimentally demonstrated a conceptually new way to test the equivalence principle that could detect the effects of a relatively new concept called spin-gravity coupling.

The study, by M. G. Tarallo, et al., is published in a recent issue of Physical Review Letters.

"Testing the equivalence principle, or the equivalence of inertial mass and gravitational mass, means testing the validity of one of the fundamental principles of general relativity," coauthor Guglielmo Tino, Professor at the University of Florence, INFN, told Phys.org. "In our experiment, we use a quantum sensor to investigate gravitational interaction; this allowed us to search for new effects."

As the researchers explain, there are a variety of ways to test the equivalence principle. These methods include studying the motion of moons and planets, the use of torsion balances, and—more recently—atom interferometry.

In the new study, the researchers have for the first time tested the equivalence principle by comparing the gravitational interaction for a bosonic particle to that of a fermionic particle. For the purpose of the experiment, the important difference between the two particles is that the bosonic particle (a strontium-88 isotope) has no spin, while the fermionic particle (a strontium-87 isotope) has a half-integer spin.

In order to determine how the differences in spin might affect a particle's gravitational interaction, the researchers performed tests to measure each isotope's acceleration due to gravity. These tests consist of confining atomic wave packets in a vertical laser standing wave, and then using a quantum effect involving delocalization to measure the effects of gravity. The new method improves the measurement precision by more than an order of magnitude over previous methods.

The results of the experiments enabled the researchers to set an upper limit of 10-7 on the boson-to-fermion gravitational constant ratio. The researchers also searched for a dependence of gravity acceleration of strontium-87 isotope on the spin direction, but found no evidence for it.

"There are theoretical models predicting that spin and gravity should couple; that is, depending on its spin a particle should behave in different ways in a gravitational field," Tino said. "We found no evidence for that. Since we compared an atom with spin with one without spin, this is a rather stringent test. Also, in our experiment one atom is a boson and the other is a fermion and, again, we found no difference in their behavior in a gravitational field."

The results could have future applications in connection with optical clocks made of strontium, which have already demonstrated impressive stability and accuracy. In the future, it may also be possible to perform an experiment in space using a strontium optical clock and a strontium interferometer to perform stringent tests of general relativity and gravity.

"Our result reported in this paper, as well as the one we recently published on the measurement of the gravitational constant with atoms (G. Rosi, et al.), shows the great potential of quantum sensors based on ultracold atoms and atom interferometry to investigate gravity," Tino said. "We want to try new schemes to increase the sensitivity of the atom interferometer; this would allow us to perform still more stringent tests and search for new effects." [10]

The Speed Of Light- Could We Be Wrong About It?

The theory of general relativity states, In a vacuum light travels at a constant speed of 299,792,458 meters per second. The speed of light, or you can say number of light years, is what we measure essentially everything in the cosmos by, so it's essential we acquire it right. Franson's paper is founded on measurements taken of the supernova SN 1987A, which shrunken and blasted in February 1987. Physicists observing the supernova collapse picked up on the occurrence of both photons and neutrinos in the detonation, as Bob Yirka reports, there was a problem.

The physicists noted a strange time for the arrival of the photons. According to their calculations, the photons were thought to reach three hours after the neutrinos and keep the same speed as they voyaged through space. But they arrived 4.7 hours late. Possibly the photons were discharged slower than estimated, some scientists proposed, or possibly the neutrinos' travelling speed was slower than estimated. The most common theory was that the photons originated from some other source completely. But what if they originated from the supernova eruption, says Franson, and their late appearance is described by light slowing down as it travels due to a property of photons recognized as 'vacuum polarisation'. Vacuum polarisation defines a procedure where an electromagnetic field sources a photon to be divided into a positron and an electron for a few moments, alters the current and charge of the electromagnetic field, and then snap back together again into a photon.

Yirka describes why this is vital: "That should create a gravitational differential, [Franson] notes, between the pair of particles, which, he theorises, would have a tiny energy impact when they recombine - enough to cause a slight bit of a slowdown during travel. If such splitting and rejoining occurred many times with many photons on a journey of 168,000 light years, the distance between us and SN 1987A, it could easily add up to the 4.7 hour delay, [Franson] suggests."

If Fransons's theory is right, every distance measured by light years is incorrect, comprising how far away the Sun and distant galaxies are from the Earth. In certain circumstances, says Yirka, astrophysicist's might have to start it all over from scratch. [9]

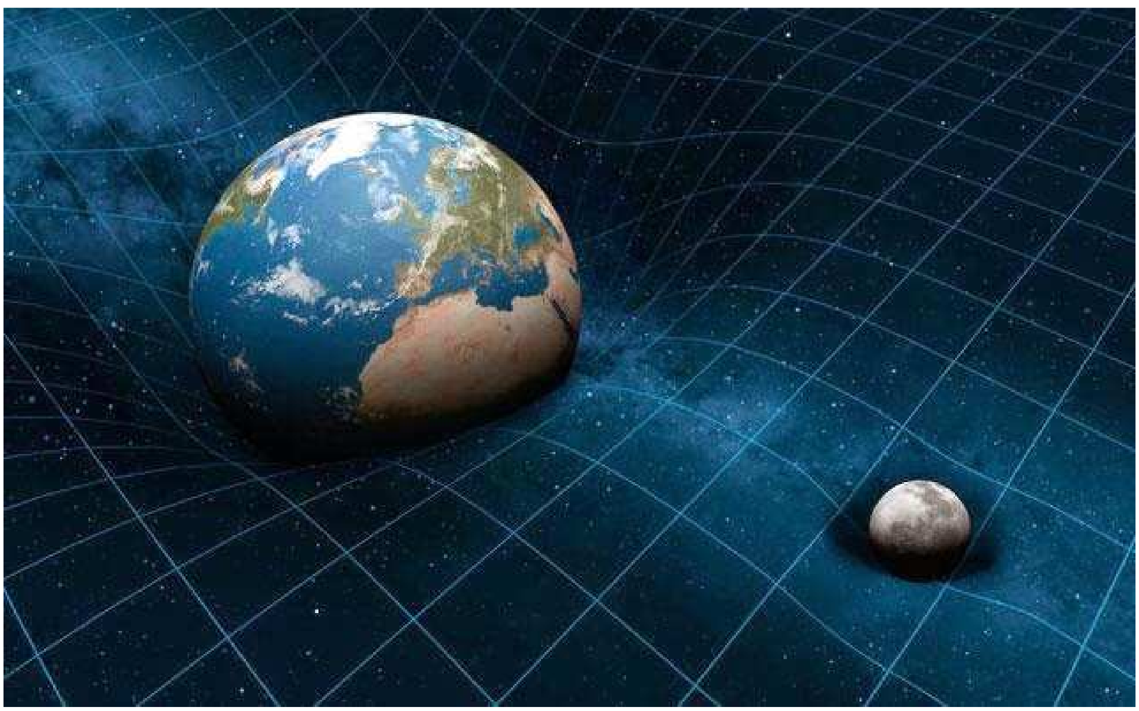
Universal decoherence due to gravitational time dilation

The physics of low-energy quantum systems is usually studied without explicit consideration of the background spacetime. Phenomena inherent to quantum theory in curved spacetime, such as Hawking radiation, are typically assumed to be relevant only for extreme physical conditions: at high energies and in strong gravitational fields. Here we consider low-energy quantum mechanics in the presence of gravitational time dilation and show that the latter leads to the decoherence of quantum superpositions. Time dilation induces a universal coupling between the internal degrees of freedom and the centre of mass of a composite particle. The resulting correlations lead to decoherence in the particle position, even without any external environment. We also show that the weak time dilation on Earth is already sufficient to affect micrometre-scale objects. Gravity can therefore account for the emergence of classicality and this effect could in principle be tested in future matter-wave experiments. [8]

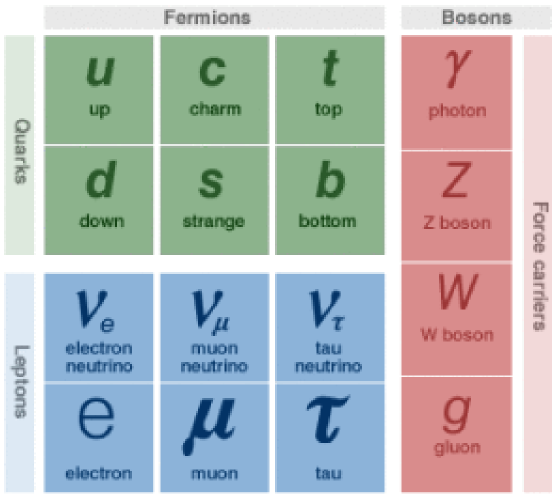
"Gravity" Fantasy or Reality

In modern physics, material in the universe is made up of quanta or "particles" such as electrons, protons and neutrons. These units can be said to relate through various forces or fields (strong, weak, electromagnetic, gravitational) for which there are matching "field quanta" such as photons and gluons. These quanta are usually understood as the particles that make up these fields, and while things are a bit more complex it is the right basic concept. We have a lot of experimental proof for these quanta, but there is one that's often stated for which we have no experimental proofs, that's the graviton.

One of the fundamental methods in quantum field theory is to begin with a wave form and then "quantize" it by the help of mathematical formalism. In this way you can display, for example, how photons ascend from the electromagnetic field. The same method can be applied with the gravitational field. Begin with gravitational waves, and then quantize it to derive gravitons. But there are some glitches with this methodology. In quantum field theory all fields act inside a flat background of space and time (named Minkowski space). Gravitational waves interfere with space and time itself, so to derive gravitons it's often supposed that the gravitational waves are a variation inside a background of Minkowski space. It this way you can take gravity as a field within flat space so that you can quantize it.



Of course, general relativity illustrates that is not how gravity works. Gravity is a result of space time curvature, so to quantize gravity you would have to quantize space time itself. Just how that might be done is one of the great unexplained mysteries in physics. So it's probable that gravitons don't exist. But it's usually considered that they do, since most physicists ponder that in the end quantum theory will be at the heart of everything. The present key approaches to quantum gravity, such as string theory and loop quantum gravity, forecast the reality of gravitons with the similar characteristics we see in the simple “quantized wave” method.



Even if gravitons are there, it’s probable that we would never be able to perceive them. As one latest paper demonstrated, gravitons would interact so weakly with masses that you would require something like a Jupiter-mass detector circling a neutron star. Even then it would take more than a decade to perceive a single graviton. Even then the noise from particles like neutrinos would wash out your signal. If there’s no applied way to sense gravitons, does it make any logic to talk of them as a scientific model?

Perhaps, assuming they continue inside a robust model of quantum gravity, there may be secondary ways of proving their actuality. For now, though, they are totally hypothetical. [7]

Quantum Gravity Measurement by Entanglement

In our idea, two quantum particles are prepared in an entangled state in between two different satellites orbiting the Earth. As long as they stay in the same orbit, the entanglement exists. However, at some point the orbit of one of the satellite needs to be changed. This is done by firing engines and accelerating to the new location.

The acceleration needed to change orbit is determined by the gravitational forces acting on the satellite: the more distant the new orbit we want to reach, the larger the time that the engines must be switched on to get the required velocity. This is due to the fact that gravity is more intense if the object is closer to the Earth.

We find that such acceleration – and thus, indirectly, gravity – changes the quality of entanglement between the two particles. If our calculations are right, this could be the first experimental proof that shows that gravity will have indirect effects on quantum entanglement. Also, if quantum technology has to be used in space, it is vital that this be taken into consideration. [6]

Quantum entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.
The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly: ds/dt = at (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate).

Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

The weak interaction

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

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

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

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

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

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

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

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

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

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

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for

example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.
The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.
We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.
There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

Fermions and Bosons

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

Van Der Waals force

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

Electromagnetic inertia and mass

Electromagnetic Induction

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

Relativistic change of mass

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

The frequency dependence of mass

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

Electron – Proton mass rate

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

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

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

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

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

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

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

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

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.

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

The Higgs boson

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

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

Higgs mechanism and Quantum Gravity

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

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

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

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

What is the Spin?

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

The Graviton

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

Conclusions

A composite particle in superposition will decohere owing to time dilation.
As one latest paper demonstrated, gravitons would interact so weakly with masses that you would require something like a Jupiter-mass detector circling a neutron star. Even then it would take more than a decade to perceive a single graviton. Even then the noise from particles like neutrinos would wash out your signal. [7]
The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]
The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]
One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .
The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing. Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions.

In the future, the researchers plan to further investigate both the fundamental and practical aspects of quantum and relativistic effects.

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