Smarter Experiments Discovery

A team of scientists from the U.S. Department of Energy's Brookhaven National Laboratory and Lawrence Berkeley National Laboratory designed, created, and successfully tested a new algorithm to make smarter scientific measurement decisions. [10]

Researchers have successfully created a model of the Universe using artificial intelligence, reports a new study. [9]

A deep-learning system that can sift gravitational wave signals from background noise has been created by physicists in the UK. [8]

Using data from the first-ever gravitational waves detected last year, along with a theoretical analysis, physicists have shown that gravitational waves may oscillate between two different forms called "g" and "f"-type gravitational waves. [7]

Astronomy experiments could soon test an idea developed by Albert Einstein almost exactly a century ago, scientists say. [6]

It's estimated that 27% of all the matter in the universe is invisible, while everything from PB&J sandwiches to quasars accounts for just 4.9%. But a new theory of gravity proposed by theoretical physicist Erik Verlinde of the University of Amsterdam found out a way to dispense with the pesky stuff. [5]

The proposal by the trio though phrased in a way as to suggest it's a solution to the arrow of time problem, is not likely to be addressed as such by the physics community—it's more likely to be considered as yet another theory that works mathematically, yet still can't answer the basic question of what is time. [4]

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 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.

Author: George Rajna

Smarter experiments for faster materials discovery

A team of scientists from the U.S. Department of Energy's Brookhaven National Laboratory and Lawrence Berkeley National Laboratory designed, created, and successfully tested a new algorithm to make smarter scientific measurement decisions. The algorithm, a form of artificial intelligence (AI), can make autonomous decisions to define and perform the next step of an experiment. The team described the capabilities and flexibility of their new measurement tool in a paper published on August 14, 2019 in *Scientific Reports*.

From Galileo and Newton to the recent discovery of gravitational waves, performing scientific experiments to understand the world around us has been the driving force of our technological advancement for hundreds of years. Improving the way researchers do their experiments can have tremendous impact on how quickly those experiments yield applicable results for new technologies.

Over the last decades, researchers have sped up their experiments through automation and an ever-growing assortment of fast measurement tools. However, some of the most interesting and important scientific challenges—such as creating improved battery materials for energy storage or new quantum materials for new types of computers—still require very demanding and time-consuming experiments.

By creating a new decision-making algorithm as part of a fully automated experimental setup, the interdisciplinary team from two of Brookhaven's DOE Office of Science user facilities—the Center for Functional Nanomaterials (CFN) and the National Synchrotron Light Source II (NSLS-II)—and Berkeley Lab's Center for Advanced Mathematics for Energy Research Applications (CAMERA) offers the possibility to study these challenges in a more efficient fashion.

The challenge of complexity

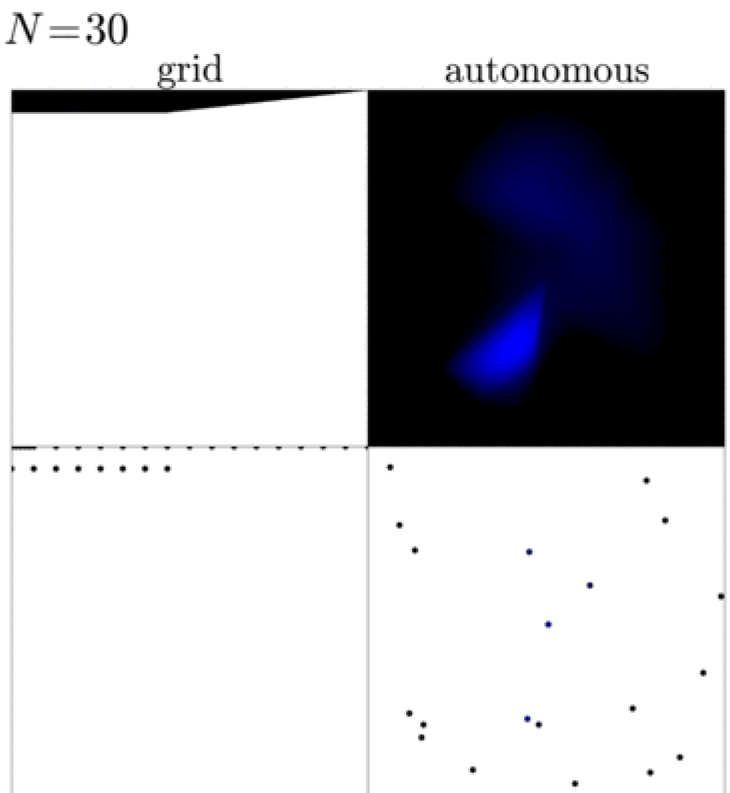
The goal of many experiments is to gain knowledge about the material that is studied, and scientists have a well-tested way to do this: They take a sample of the material and measure how it reacts to changes in its environment.

A standard approach for scientists at user facilities like NSLS-II and CFN is to manually scan through the measurements from a given experiment to determine the next area where they might want to run an experiment. But access to these facilities' high-end materials-characterization tools is limited, so measurement time is precious. A research team might only have a few days to measure their materials, so they need to make the most out of each measurement.

"The key to achieving a minimum number of measurements and maximum quality of the resulting model is to go where uncertainties are large," said Marcus Noack, a postdoctoral scholar at CAMERA and lead author of the study. "Performing measurements there will most effectively reduce the overall model uncertainty."

As Kevin Yager, a co-author and CFN scientist, pointed out, "The final goal is not only to take data faster but also to improve the quality of the data we collect. I think of it as experimentalists switching from micromanaging their experiment to managing at a higher level. Instead of having to decide where to measure next on the sample, the scientists can instead think about the big picture, which is ultimately what we as scientists are trying to do."

"This new approach is an applied example of artificial intelligence," said co-author Masafumi Fukuto, a scientist at NSLS-II. "The decision-making algorithm is replacing the intuition of the human experimenter and can scan through the data and make smart decisions about how the experiment should proceed."



This animation shows a comparison between a traditional grid measurement (left) of a sample with a measurement steered by the newly-developed decision-making algorithm (right). This comparison shows that the algorithm can identify the edges and inner part of the sample and focuses the measurement in these regions to gain more knowledge about the sample. Credit: Brookhaven National Laboratory

More information for less?

In practice, before starting an experiment, the scientists define a set of goals they want to get out of the measurement. With these goals set, the algorithm looks at the previously measured data while the experiment is ongoing to determine the next measurement. On its search for the best next measurement, the algorithm creates a surrogate model of the data, which is an educated guess as to how the material will behave in the next possible steps, and calculates the uncertainty—basically how confident it is in its guess—for each possible next step. Based on this, it then selects the most uncertain option to measure next. The trick here is by picking the most uncertain step to measure next, the algorithm maximizes the amount of knowledge it gains by making that measurement. The algorithm not only maximizes the information gain during the measurement, it also defines when to end the experiment by figuring out the moment when any additional measurements would not result in more knowledge.

"The basic idea is, given a bunch of experiments, how can you automatically pick the next best one?" said James Sethian, director of CAMERA and a co-author of the study. "Marcus has built a world which builds an approximate surrogate model on the basis of your previous experiments and suggests the best or most appropriate experiment to try next."

How we got here

To make autonomous experiments a reality, the team had to tackle three important pieces: the automation of the data collection, real-time analysis, and, of course, the decision-making algorithm.

"This is an exciting part of this collaboration," said Fukuto. "We all provided an essential piece for it: The CAMERA team worked on the decision-making algorithm, Kevin from CFN developed the real-time data analysis, and we at NSLS-II provided the automation for the measurements."

The team first implemented their decision-making algorithm at the Complex Materials Scattering (CMS) beamline at NSLS-II, which the CFN and NSLS-II operate in partnership. This instrument offers ultrabright x-rays to study the nanostructure of various materials. As the lead beamline scientist of this instrument, Fukuto had already designed the beamline with automation in mind. The beamline offers a sample-exchanging robot, automatic sample movement in various directions, and many other helpful tools to ensure fast measurements. Together with Yager's real-time data analysis, the beamline was—by design—the perfect fit for the first "smart" experiment.

The first "smart" experiment

The first fully autonomous experiment the team performed was to map the perimeter of a droplet where nanoparticles segregate using a technique called small-angle X-ray scattering at the CMS beamline. During small-angle X-ray scattering, the scientists shine bright x-rays at the sample and, depending on the atomic to nanoscale structure of the sample, the x-rays bounce off in different directions. The scientists then use a large detector to capture the scattered x-rays and calculate the properties of the sample at the illuminated spot. In this first experiment, the scientists compared the standard approach of measuring the sample with measurements taken when the new decision-making algorithm was calling the shots. The algorithm was able to identify the area of the droplet and focused on its edges and inner parts instead of the background.

"After our own initial success, we wanted to apply the algorithm more, so we reached out to a few users and proposed to test our new algorithm on their scientific problems," said Yager. "They said yes, and since then we have measured various samples. One of the most interesting ones was a study on a sample that was fabricated to contain a spectrum of different material types. So instead of making and measuring an enormous number of samples and maybe missing an interesting combination, the user made one single sample that included all possible combinations. Our algorithm was then able to explore this enormous diversity of combinations efficiently," he said.

What's next?

After the first successful experiments, the scientists plan to further improve the algorithm and therefore its value to the scientific community. One of their ideas is to make the algorithm "physics-aware"—taking advantage of anything already known about material under study—so the method can be even more effective. Another development in progress is to use the algorithm during synthesis and processing of new materials, for example to understand and optimize processes relevant to advanced manufacturing as these materials are incorporated into real-world devices. The team is also thinking about the larger picture and wants to transfer the autonomous method to other experimental setups.

"I think users view the beamlines of NSLS-II or microscopes of CFN just as powerful characterization tools. We are trying to change these capabilities into a powerful material discovery facility," Fukuto said. [10]

AI learns to model our Universe

Researchers have successfully created a model of the Universe using artificial intelligence, reports a new study.

Researchers seek to understand our Universe by making model predictions to match observations. Historically, they have been able to model simple or highly simplified physical systems, jokingly dubbed the "spherical cows," with pencils and paper. Later, the arrival of computers enabled them to model complex phenomena with numerical simulations. For example, researchers have programmed supercomputers to simulate the motion of billions of particles through billions of years of cosmic time, a procedure known as the N-body simulations, in order to study how the Universe evolved to what we observe today.

"Now with machine learning, we have developed the first neural network model of the Universe, and demonstrated there's a third route to making predictions, one that combines the merits of both analytic calculation and numerical simulation," said Yin Li, a Postdoctoral Researcher at the Kavli Institute for the Physics and Mathematics of the Universe, University of Tokyo, and jointly the University of California, Berkeley.

A comparison of the accuracy of two models of the Universe. The new deep learning model (left), dubbed D3M, is much more accurate than an existing analytic method (right) called 2LPT. The colors represent the error in displacement at each point relative to the numerical simulation, which is accurate but much slower than the deep learning model.

At the beginning of our Universe, things were extremely uniform. As time went by, the denser parts grew denser and sparser parts became sparser due to gravity, eventually forming a foam-like structure known as the "cosmic web." To study this structure formation process, researchers have tried many methods, including analytic calculations and numerical simulations. Analytic methods are fast, but fail to produce accurate results for large density fluctuations. On the other hand, numerical (N-body) methods simulate structure formation accurately, but tracking gazillions of particles is costly, even on supercomputers. Thus, to model the Universe, scientists often face the accuracy versus efficiency trade-off.

However, the explosive growth of observational data in quality and quantity calls for methods that excel in both accuracy and efficiency.

To tackle this challenge, a team of researchers from the US, Canada, and Japan, including Li, set their sights on machine learning, a cutting-edge approach to detecting patterns and making predictions. Just as machine learning can transform a young man's portrait into his older self, Li and colleagues asked whether it can also predict how universes evolve based on their early snapshots. They trained a convolutional neural network with simulation data of trillions of cubic light years in volume, and built a deep learning model that was able to mimic the structure formation process. The new model is not only many times more accurate than the analytic methods, but is also much more efficient than the numerical simulations used for its training.

"It has the strengths of both previous [analytic calculation and numerical simulation] methods," said Li.

Li says the power of AI emulation will scale up in the future. N-body simulations are already heavily optimized, and as a first attempt, his team's AI model still has large room for improvement. Also, more complicated phenomena incur a larger cost on simulation, but not likely so on emulation. Li and his colleagues expect a bigger performance gain from their AI emulator when they move on to including other effects, such as hydrodynamics, into the simulations.

"It won't be long before we can uncover the initial conditions of and the physics encoded in our Universe along this path," he said. [9]

Artificial intelligence spots gravitational waves

A deep-learning system that can sift gravitational wave signals from background noise has been created by physicists in the UK. Deep learning is a neural-inspired pattern recognition technique that has already been applied to image processing, speech recognition and medical diagnoses, among other things. Chris Messenger and colleagues at the University of Glasgow have shown that their system is as effective as conventional signal processing and has the potential to identify gravitational-wave signals much more quickly.

Gravitational waves are ripples in space-time that can be observed using the LIGO-Virgo detectors – which are laser interferometers with pairs of arms several kilometres long positioned at right angles to each other. As a wave passes through the Earth it very slightly stretches one arm while squeezing the other, before squeezing the first and stretching the second, and so on. This generates a series of tiny but distinctive oscillations that are recorded as variations in the interference patterns measured by the instruments.

The first gravitational wave to be detected was snared by the two LIGO detectors in the US in September 2015. Unlike signals observed since then, these oscillations were visible to the naked eye within the raw data. Normally gravitational-wave signals are swamped by noise – seismic, thermal motion or photon statistics – that must be filtered out using computer algorithms if the signal is to emerge.

Template matching

Usually signals are picked out from the noise using a technique known as matched filtering. This involves comparing the oscillations recorded by the interferometer with a series of templates representing waveforms produced by different astrophysicals event that are calculated using post-Newtonian and relativistic equations. A significant match between the observational data and any of the templates means a detection, while the type of waveform in the template reveals what caused the gravitational wave in question.

However, the need to compare large numbers of templates to ensure an accurate result means that matched filtering requires lots of processing power and is time-consuming. In the latest work, the team has shown they can potentially reduce the time needed – by using machine learning rather than conventional algorithms. Their system relies on a neural network, which, like the brain, consists of layers of processing units that fire when they receive a certain input.

The system's input layer holds the raw data that would come from an interferometer – a series of numbers related to variations in the arms' strain. These data are fed to the first of nine internal layers made up of neurons whose output depends on the input data and a weighting applied to each neuron. With those outputs then forming the inputs of the next layer, and so on, the system ends in a final layer consisting of just two neurons that each generate a probability value between 0 and 1. One neuron reveals how likely it is that the raw data contain a signal while the other, conversely, describes the likelihood of it containing just noise.

Training weights

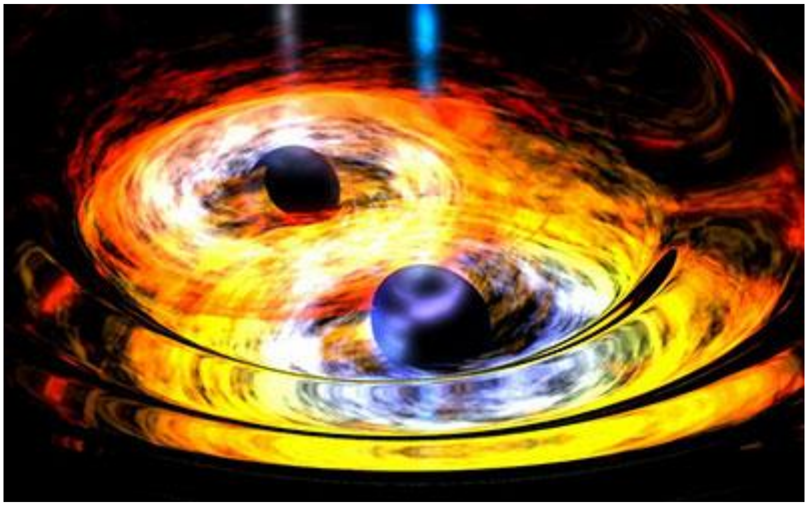
Initially the neurons' weights are set randomly and the system is "trained" by exposing it to a series of sample data sets, half of which consist of a gravitational-wave signal from binary black-hole mergers covered by "Gaussian" noise while the other half contain Gaussian noise only. The probability values computed by the system in each case are compared with the (known) data type – signal or noise – and the degree of error is then used to adjust the neuron weights layer by layer in a process called back propagation. The idea is that after enough iterations, the network can distinguish signal from noise reliably.

Having trained their system with half a million data sets, Messenger and co-workers then fed it 20,000 new waveforms to see how many it could correctly identify. They also analysed the same set of waveforms using matched filtering. They found that the two techniques performed nearly equally – their ability to find the buried signals depending in a very similar way on the signal-to-noise ratio and on the probability of mistaking noise for signal. However, because the bulk of computation for deep learning occurs during training, the new technique was far quicker – taking just a few seconds to analyse all the unknown waveforms rather than several hours.

According to Glasgow group member Hunter Gabbard, this greater speed might prove handy as interferometers become more sensitive and detect gravitational waves more often. This, he says, could help alert astronomers to signals from merging neutron stars so that they can point their telescopes to the patch of sky in question and pick up the accompanying electromagnetic radiation before it disappears.

Recognizing glitches

The Glasgow group, however, is not the only one to have applied artificial intelligence to gravitational-wave detection. In particular, Daniel George and Eliu Huerta of the University of Illinois in the US have already published two papers showing that deep learning can operate orders of magnitude faster than matched filtering. They have also used their neural network to estimate properties of gravitational-wave signals, such as the masses of radiating black holes, as well as analysing real, as opposed to simulated, LIGO data. Such data, they point out, can contain what are known as glitches – noise that can mimic a signal – as well as purely Gaussian noise.



LIGO detects first ever gravitational waves – from two merging black holes

Rory Smith of Monash University in Australia is slightly more cautious about the potential for deep learning. He says it "could one day show promise", suggesting it might prove particularly useful for distinguishing astrophysical signals from glitches, but prefers to develop more physics-based "principled" approaches. "There's still a lot of room to better understand the signals and data that we have without resorting to black-box techniques," he argues.

Messenger and colleagues describe their work in *Physical Review Letters*. [8]

Gravitational waves may oscillate, just like neutrinos

Using data from the first-ever gravitational waves detected last year, along with a theoretical analysis, physicists have shown that gravitational waves may oscillate between two different forms called "g" and "f"-type gravitational waves. The physicists explain that this phenomenon is analogous to the way that neutrinos oscillate between three distinct flavors—electron, muon, and tau. The oscillating gravitational waves arise in a modified theory of gravity called bimetric gravity, or "bigravity," and the physicists show that the oscillations may be detectable in future experiments.

The researchers, Kevin Max, a PhD student at Scuola Normale Superiore di Pisa and INFN Pisa, Italy; Moritz Platscher, a PhD student at the Max Planck Institute for Nuclear Physics, Germany; and Juri Smirnov, a postdoc at the University of Florence, Italy, have published a paper on their analysis of gravitational wave oscillations in a recent issue of Physical Review Letters.

As the physicists explain, the work may help answer the question of what "the other 95%" of the universe is made of, by suggesting that the answer may lie in modifications to gravity rather than new particles.

"Only 5% of matter is of a type we think to understand properly," Smirnov told Phys.org. "To address the question of what our universe is made of ('dark matter' and 'dark energy'), most authors discuss alternative particle physics models with new particles. However, experiments such as the ones at the LHC [Large Hadron Collider] haven't detected any exotic particles, yet. This raises the question if maybe the gravitational side needs to be modified.

"In our work, we ask what signals we could expect from a modification of gravity, and it turns out that bigravity features a unique such signal and can therefore be discriminated from other theories. The recent detection of gravitational waves by LIGO [Laser Interferometer Gravitational-Wave Observatory] has opened a new window on the dark sectors of the universe for us. Whether Nature has chosen general relativity, bigravity, or any other theory is a different question in the end. We can only study possible signals for experimentalists to look for."

Two gravitons instead of one

Currently, the best theory of gravity is Einstein's theory of general relativity, which uses a single metric to describe spacetime. As a result, gravitational interactions are mediated by a single hypothetical particle called a graviton, which is massless and so travels at the speed of light.

The main difference between general relativity and bigravity is that bigravity uses two metrics, g and f. Whereas g is a physical metric and couples to matter, f is a sterile metric and does not couple to matter. In bigravity, gravitational interactions are mediated by two gravitons, one of which has mass and the other of which is massless. The two gravitons are composed of different combinations (or superpositions) of the g and f metrics, and so they couple to the surrounding matter in different ways. The existence of two metrics (and two gravitons) in the bigravity framework eventually leads to the oscillation phenomenon.

As the physicists explain, the idea that there might exist a graviton with mass has been around since almost as long general relativity itself.

"Einstein's theory of general relativity predicts one mediator (the 'graviton') of the gravitational interactions, which travels at the speed of light, i.e., which is massless," Max said. "Back in the late 1930s, people were already trying to find a theory containing a mediator that has a mass, and thus travels at a speed less than the speed of light. This turned out to be a very difficult task and was only recently accomplished in 2010. Bigravity is a variation of this 2010 framework, which features not one, but two dynamical metrics. Only one of them couples to matter while the other doesn't;

and a linear combination of them becomes massive (slower than the speed of light) while the other is massless (speed of light)."

Oscillations

The physicists show that, in the framework of bigravity, as gravitational waves are produced and propagate through space, they oscillate between the g- and f-types—though only the g-type can be detected. Although previous research has suggested that these oscillations might exist, it appeared to lead to unphysical results, such as a violation of energy conservation. The new study shows that the oscillations can theoretically emerge in a realistic physical scenario when considering graviton masses that are large enough to be detected by current astrophysical tests.

In order to understand these oscillations, the scientists explain that in many ways they resemble neutrino oscillations. Although neutrinos come in three flavors (electron, muon, and tau), typically the neutrinos produces in nuclear reactions are electron neutrinos (or electron anti-neutrinos) because the others are too heavy to form stable matter. In a similar way, in bigravity only the g metric couples to matter, so the gravitational waves produced by astrophysical events, such as black hole mergers, are g-type since f-type gravitational waves do not couple to matter.

"The key to understanding the oscillation phenomenon is that electron neutrinos do not have a definite mass: they are a superposition of the three neutrino mass eigenstates," Platscher explained. "More mathematically speaking, the mass matrix is not diagonal in the flavor (electron-muon-tau) basis. Therefore, the wave equation that describes how they move through space will mix them up and therefore they 'oscillate.'

"The same is true in bigravity: g is a mixture of the massive and the massless graviton, and therefore as the gravitational wave travels through the Universe, it will oscillate between g- and f-type gravitational waves. However, we can only measure the former with our detectors (which are made of matter), while the latter would pass through us unseen! This would, if bigravity is a correct description of Nature, leave an important imprint in the gravitational wave signal, as we have shown."

As the physicists note, the similarity between neutrinos and gravitational waves holds even though neutrino oscillation is a quantum mechanical phenomenon that is described by the Schrödinger wave equation, whereas gravitational wave oscillation is not a quantum effect and instead is described by a classical wave equation.

One particular effect that the physicists predict is that gravitational wave oscillations lead to larger strain modulations compared to those predicted by general relativity. These results suggest a path toward experimentally detecting gravitational wave oscillations and finding support for bigravity.

"Since bigravity is a very young theory, there is still a lot to be done, and its potential to address our theories' shortcomings needs to be explored," Smirnov said. "There has been some work along these lines, but certainly a lot is yet to be done and we hope to contribute in the future as well!" [7]

Quest to settle riddle over Einstein's theory may soon be over

Astronomy experiments could soon test an idea developed by Albert Einstein almost exactly a century ago, scientists say.

Tests using advanced technology could resolve a longstanding puzzle over what is driving the accelerated expansion of the Universe.

Researchers have long sought to determine how the Universe's accelerated expansion is being driven. Calculations in a new study could help to explain whether dark energy- as required by Einstein's theory of general relativity - or a revised theory of gravity are responsible.

Einstein's theory, which describes gravity as distortions of space and time, included a mathematical element known as a Cosmological Constant. Einstein originally introduced it to explain a static universe, but discarded his mathematical factor as a blunder after it was discovered that our Universe is expanding.

Research carried out two decades ago, however, showed that this expansion is accelerating, which suggests that Einstein's Constant may still have a part to play in accounting for dark energy. Without dark energy, the acceleration implies a failure of Einstein's theory of gravity across the largest distances in our Universe.

Scientists from the University of Edinburgh have discovered that the puzzle could be resolved by determining the speed of gravity in the cosmos from a study of gravitational waves -space-time ripples propagating through the universe.

The researchers' calculations show that if gravitational waves are found to travel at the speed of light, this would rule out alternative gravity theories, with no dark energy, in support of Einstein's Cosmological Constant. If however, their speed differs from that of light, then Einstein's theory must be revised.

Such an experiment could be carried out by the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the US, whose twin detectors, 2000 miles apart, directly detected gravitational waves for the first time in 2015.

Experiments at the facilities planned for this year could resolve the question in time for the 100th anniversary of Einstein's Constant.

The study, published in Physics Letters B, was supported by the UK Science Technology Facilities Council, the Swiss National Science Foundation, and the Portuguese Foundation of Science and Technology.

Dr Lucas Lombriser, of the University of Edinburgh's School of Physics and Astronomy, said: "Recent direct gravitational wave detection has opened up a new observational window to our Universe. Our results give an impression of how this will guide us in solving one of the most fundamental problems in physics." [6]

NEW THEORY OF GRAVITY DOES AWAY WITH NEED FOR DARK MATTER

Let's be honest. Dark matter's a pain in the butt. Astronomers have gone to great lengths to explain why is must exist and exist in huge quantities, yet it remains hidden. Unknown. Emitting no visible energy yet apparently strong enough to keep galaxies in clusters from busting free like wild horses, it's everywhere in vast quantities. What is the stuff – axions, WIMPS, gravitinos, Kaluza Klein particles?

It's estimated that 27% of all the matter in the universe is invisible, while everything from PB&J sandwiches to quasars accounts for just 4.9%. But a new theory of gravity proposed by theoretical physicist Erik Verlinde of the University of Amsterdam found out a way to dispense with the pesky stuff.

Unlike the traditional view of gravity as a fundamental force of nature, Verlinde sees it as an emergent property of space. Emergence is a process where nature builds something large using small, simple pieces such that the final creation exhibits properties that the smaller bits don't. Take a snowflake. The complex symmetry of a snowflake begins when a water droplet freezes onto a tiny dust particle. As the growing flake falls, water vapor freezes onto this original crystal, naturally arranging itself into a hexagonal (six-sided) structure of great beauty. The sensation of temperature is another emergent phenomenon, arising from the motion of molecules and atoms.

So too with gravity, which according to Verlinde, emerges from entropy. We all know about entropy and messy bedrooms, but it's a bit more subtle than that. Entropy is a measure of disorder in a system or put another way, the number of different microscopic states a system can be in. One of the coolest descriptions of entropy I've heard has to do with the heat our bodies radiate. As that energy dissipates in the air, it creates a more disordered state around us while at the same time decreasing our own personal entropy to ensure our survival. If we didn't get rid of body heat, we would eventually become disorganized (overheat!) and die.

The more massive the object, the more it distorts space-time, shown here as the green mesh. Earth orbits the Sun by rolling around the dip created by the Sun's mass in the fabric of space-time. It doesn't fall into the Sun because it also possesses forward momentum. Credit: LIGO/T. Pyle

Emergent or entropic gravity, as the new theory is called, predicts the exact same deviation in the rotation rates of stars in galaxies currently attributed to dark matter. Gravity emerges in Verlinde's view from changes in fundamental bits of information stored in the structure of space-time, that four-dimensional continuum revealed by Einstein's general theory of relativity. In a word, gravity is a consequence of entropy and not a fundamental force.

Space-time, comprised of the three familiar dimensions in addition to time, is flexible. Mass warps the 4-D fabric into hills and valleys that direct the motion of smaller objects nearby. The Sun doesn't so much "pull" on the Earth as envisaged by Isaac Newton but creates a great pucker in space-time that Earth rolls around in.

In a 2010 article, Verlinde showed how Newton's law of gravity, which describes everything from how apples fall from trees to little galaxies orbiting big galaxies, derives from these underlying microscopic building blocks.

His latest paper, titled Emergent Gravity and the Dark Universe, delves into dark energy's contribution to the mix. The entropy associated with dark energy, a still-unknown form of energy responsible for the accelerating expansion of the universe, turns the geometry of spacetime into an elastic medium.

"We find that the elastic response of this 'dark energy' medium takes the form of an extra 'dark' gravitational force that appears to be due to 'dark matter'," writes Verlinde. "So the observed dark matter phenomena is a remnant, a memory effect, of the emergence of spacetime together with the ordinary matter in it."

Rotation curve of the typical spiral galaxy M 33 (yellow and blue points with errorbars) and the predicted one from distribution of the visible matter (white line). The discrepancy between the two curves is accounted for by adding a dark matter halo surrounding the galaxy. Credit: Public domain / Wikipedia

This diagram shows rotation curves of stars in M33, a typical spiral galaxy. The vertical scale is speed and the horizontal is distance from the galaxy's nucleus. Normally, we expect stars to slow down the farther they are from galactic center (bottom curve), but in fact they revolve much faster (top curve). The discrepancy between the two curves is accounted for by adding a dark matter halo surrounding the galaxy.

I'll be the first one to say how complex Verlinde's concept is, wrapped in arcane entanglement entropy, tensor fields and the holographic principal, but the basic idea, that gravity is not a fundamental force, makes for a fascinating new way to look at an old face.

Physicists have tried for decades to reconcile gravity with quantum physics with little success. And while Verlinde's theory should be rightly be taken with a grain of salt, he may offer a way to combine the two disciplines into a single narrative that describes how everything from falling apples to black holes are connected in one coherent theory. [5]

Identification of a Gravitational Arrow of Time

The proposal by the trio though phrased in a way as to suggest it's a solution to the arrow of time problem, is not likely to be addressed as such by the physics community—it's more likely to be considered as yet another theory that works mathematically, yet still can't answer the basic question of what is time.

For all the advances made in understanding the world around us, there are still two very basic fundamental concepts that have defied explanation: time and gravity. Though we have progressed greatly in measuring both and using both to understand other concepts, we still today are no closer to understanding either than we were when we first conceptualized them. Such an acknowledgment suggests that we likely have a major flaw in our understanding of the universe. In considering such a possibility, the three physicists with this new effort suggest we might look at time in a completely new way—by dividing a dynamically closed universe (ala the Newtonian N-body problem) into two halves with shape complexity growing from a single point—each solution to the problem can then be considered as having one past but two distinctly futures. In such a scenario, an observer would of necessity have to exist on one side or the other, and thus would only ever have that perspective. Critical to this idea is that the all of the energy and angular momentum in such a system would have to be zero.

In essence, the team has removed time from mathematical functions that describe the energy of the universe—that's what allows for splitting the equations that have been created to describe the evolution of the universe into two parts, with both having initial low complexity moving to higher complexity (similar in some respects to theories of time based on entropy).

The proposal by the trio though phrased in a way as to suggest it's a solution to the arrow of time problem, is not likely to be addressed as such by the physics community—it's more likely to be considered as yet another theory that works mathematically, yet still can't answer the basic question of what is time. [4]

Asymmetry in the interference occurrences of oscillators

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

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

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

(1) $I = I_0 \sin^2 n\ \varphi/2\ \mathbf{/}\ \sin^2 \varphi/2$

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

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

This gives us the idea of

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

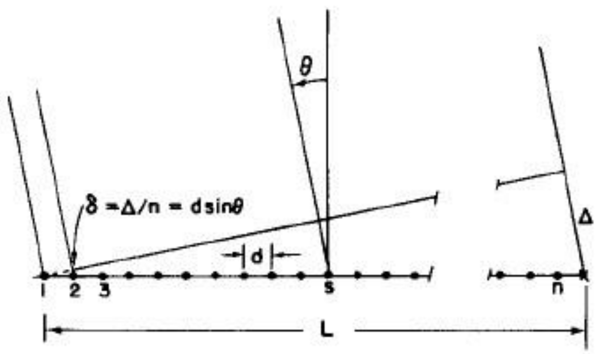


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

Figure 1.) A linear array of n equal oscillators

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

So

(4) d sin Θ = m λ 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 Θ = 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:

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

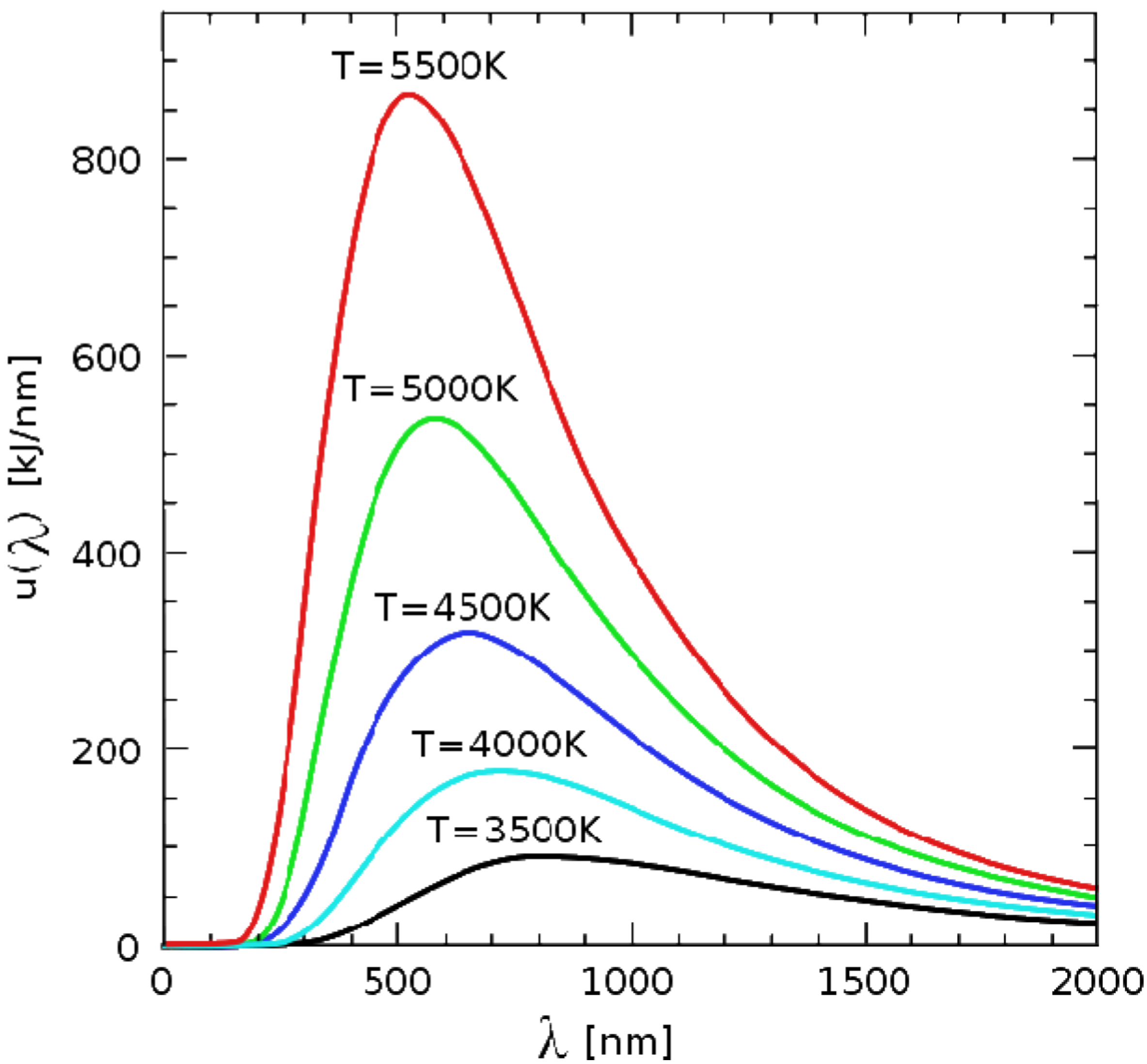


Figure 2. The distribution law for different T temperatures

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 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 order, 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.

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.

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 $\lambda\nu = c$, 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.

Conclusions

In essence, the team has removed time from mathematical functions that describe the energy of the universe—that's what allows for splitting the equations that have been created to describe the evolution of the universe into two parts, with both having initial low complexity moving to higher complexity (similar in some respects to theories of time based on entropy). [4]

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. 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. 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.

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://phys.org/news/2014-11-physicists-identification-gravitational-arrow.html [5] NEW THEORY OF GRAVITY DOES AWAY WITH NEED FOR DARK MATTER

http://www.universetoday.com/131901/new-theory-of-gravity-does-away-with-need-for-darkmatter/

[6] Quest to settle riddle over Einstein's theory may soon be over

https://phys.org/news/2017-02-quest-riddle-einstein-theory.html

[7] Gravitational waves may oscillate, just like neutrinos

https://phys.org/news/2017-09-gravitational-oscillate-neutrinos.html

[8] Artificial intelligence spots gravitational waves

https://physicsworld.com/a/artificial-intelligence-spots-gravitational-waves/

[9] AI learns to model our Universe

https://phys.org/news/2019-08-ai-universe.html

[10] Smarter experiments for faster materials discovery

https://phys.org/news/2019-08-smarter-faster-materials-discovery.html