Multiple Copies of the Standard Model

In the proposed model, the universe contains multiple sectors, each of which is governed by its own version of the Standard Model with its own Higgs vacuum expectation value. The sector with the smallest non-zero vacuum expectation value contains our copy of the Standard Model. [18]

Physicists have come up with a new model that they say solves five of the biggest unanswered questions in modern physics, explaining the weirdness of dark matter, neutrino oscillations, baryogenesis, cosmic inflation, and the strong CP problem all at once. [17]

The universe is unbalanced. Gravity is tremendously weak. But the weak force, which allows particles to interact and transform, is enormously strong. The mass of the Higgs boson is suspiciously petite. And the catalog of the makeup of the cosmos? Ninety-six percent incomplete. [16]

One of the biggest challenges in physics is to understand why everything we see in our universe seems to be formed only of matter, whereas the Big Bang should have created equal amounts of matter and antimatter.

CERN's LHCb experiment is one of the best hopes for physicists looking to solve this longstanding mystery. [15]

Imperial physicists have discovered how to create matter from light - a feat thought impossible when the idea was first theorized 80 years ago. [14]

How can the LHC experiments prove that they have produced dark matter? They can’t… not alone, anyway. [13]

The race for the discovery of dark matter is on. Several experiments worldwide are searching for the mysterious substance and pushing the limits on the properties it may have. [12]

Dark energy is a mysterious force that pervades all space, acting as a "push" to accelerate the universe's expansion. Despite being 70 percent of the universe, dark energy was only discovered in 1998 by two teams observing Type Ia supernovae. A Type 1a supernova is a cataclysmic explosion of a white dwarf star. The best way of measuring dark energy just got better, thanks to a new study of Type Ia supernovae. [11]

Newly published research reveals that dark matter is being swallowed up by dark energy, offering novel insight into the nature of dark matter and dark energy and what the future of our Universe might be. [10]

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.

Contents

Author: George Rajna

Multiple copies of the Standard Model could solve the hierarchy problem

One of the unanswered questions in particle physics is the hierarchy problem, which has implications for understanding why some of the fundamental forces are so much stronger than others. The strengths of the forces are determined by the masses of their corresponding force-carrying particles (bosons), and these masses in turn are determined by the Higgs field, as measured by the Higgs vacuum expectation value.

So the hierarchy problem is often stated as a problem with the Higgs field: specifically, why is the Higgs vacuum expectation value so much smaller than the largest energy scales in the universe, in particular the scale at which gravity (by far the weakest of the forces) becomes strong? Reconciling this apparent discrepancy would impact physicists' understanding of particle physics at the most fundamental level.

"The hierarchy problem is one of the deepest questions in particle physics, and almost every one of its known solutions corresponds to a different vision of the universe," Raffaele Tito D'Agnolo, a physicist at Princeton, told Phys.org. "Identifying the correct answer will not just solve a conceptual puzzle, but will change the way we think about particle physics."

In a new paper published in Physical Review Letters, D'Agnolo and his coauthors have proposed a solution to the hierarchy problem that involves multiple (up to 1016) copies of the Standard Model, each with a different Higgs vacuum expectation value. In this model, the universe consists of many sectors, each of which is governed by its own version of the Standard Model with its own Higgs vacuum expectation value. Our sector is the one with the smallest nonzero value.

If, in the very early universe, all sectors had comparable temperatures and seemingly equal chances of dominating, why did our sector, with the smallest nonzero Higgs vacuum expectation value, come to dominate? The physicists introduce a new mechanism called a "reheaton field" that explains this by reheating the universe as it decays. The physicists show that there are several ways in which the reheaton field could have preferentially decayed into and deposited the majority of its energy into the sector with the smallest Higgs vacuum expectation value, causing this sector to eventually dominate and become our observable universe.

Compared to other proposed solutions to the hierarchy problem, such as supersymmetry and extra dimensions, the new proposal—which the physicists call "N-naturalness"—is different in that the solution does not rely solely on new particles. Although the new proposal shares some features with both supersymmetry and extra dimensions, one of its unique characteristics is that it is not only new particles, but more importantly cosmological dynamics, that is central to the solution.

"N-naturalness is qualitatively different from the solutions to the hierarchy problem proposed in the past, and it predicts signals in cosmic microwave background (CMB) experiments and large-scale structure surveys, two probes of nature that were thought to be unrelated to the problem," D'Agnolo said.

As the physicists explain, it should be possible to detect signatures of N-naturalness by searching for signs of the existence of other sectors. For instance, future CMB experiments might detect extra radiation and changes in neutrino cosmology, since neutrinos in nearby sectors are expected to be slightly heavier and less abundant than those in our sector. This approach is interesting for another reason: the neutrinos in the other sectors are also a viable dark matter candidate, which the researchers plan to study in more detail. Future experiments might also find signatures of N-naturalness in the form of a larger-than-expected mass of axion particles, as well as supersymmetric signatures due to possible connections to supersymmetry.

"If new relativistic species are not detected by the next generation of CMB experiments (Stage 4), then I will stop thinking of N-naturalness as a possible solution to the hierarchy problem," D'Agnolo said. "According to the current timeline, these experiments should start taking data around 2020 and reach their physics goals in approximately five years." [18]

This new hypothesis claims to solve 5 of the biggest problems in physics

Physicists have come up with a new model that they say solves five of the biggest unanswered questions in modern physics, explaining the weirdness of dark matter, neutrino oscillations, baryogenesis, cosmic inflation, and the strong CP problem all at once.

The new model, called SMASH, proposes that we only need six new particles to reconcile all of these gaps in the standard model of physics, and the team behind it says it won’t be that hard to test.

The model has been developed by a team of French and German physicists, and they say it doesn’t require any major tweaks to the standard model - just a few new additions.

It’s early days yet, but that’s a pretty cool proposition, because other models designed to explain the mysteries of quantum mechanics - such as supersymmetry - require the addition of hundreds of new particles that we’ve never even seen traces of.

SMASH, on the other hand, requires just six: three neutrinos, a fermion, and a field that includes two particles. (In physics, a field is a physical or mathematical entity that has a value for each point in space and time. A particle is an excited state of a field.)

To give you an idea of what these five fundamental problems are, we’ll run through them all, starting with dark matter.

1. Dark matter

There is now overwhelming evidence that 26-27 percent of the Universe is made up of an unidentified type of matter. While we can detect its gravitational force, this unknown matter doesn't appear to emit any form of light or radiation that we can observe.

Despite years of searching, we still have no idea what dark matter actually consists of, but we do know that its presence is crucial to the stability of the Universe.

2. Neutrino oscillations

Last year, the Nobel Prize in Physics was awarded to two physicists who proved that neutrinos could oscillate between ‘flavours’.

Neutrino oscillation is a quantum mechanical phenomenon where a neutrino created with a specific lepton flavour (such as an electron, a muon, or a tau) can have a different flavour later on.

Because only particles with mass can switch flavours - or oscillate - neutrinos must have mass, and this presents a problem for the standard model, because no one knows where neutrino mass actually comes from.

It could come from the Higgs boson, but it could also come from an entirely new particle we’ve yet to discover.

3. Baryogenesis

This major unsolved problem in physics can be summed up pretty simply: Why does the observable Universe have more matter than antimatter?

According to the standard model, the Big Bang would have produced equal amounts of matter and antimatter, and since they annihilate each another on contact, this should have led to a Universe with no particles - just radiation.

Obviously the fact that there are a whole lot of particles in the Universe means that there's something wrong with this scenario, because how can there be so much matter in the Universe now, but almost no antimatter?

4. Cosmic Inflation

It's thought that within a fraction of a second after the Big Bang, the Universe underwent a period of accelerated expansion called inflation.

While most physicists accept the reality of cosmic inflation, no one's been able to figure out the exact mechanism responsible for making the Universe expand faster than the speed of light, going from subatomic-sized to golf-ball-sized almost instantaneously.

A hypothetical field has been proposed as the main cause of inflation, called the inflaton, but we're yet to actually detect it.

5. The strong CP problem

Described as a "serious flaw of the standard model", the strong CP problem helps to explain why there is more matter than antimatter in the Universe, but brings its own unsolved mysteries with it.

This one's a particularly long story, but in a nutshell, the strong CP problem describes how CP violation - a break in the fundamental symmetry of the Universe - doesn't occur in quantum chromodynamics (QCD), which relates to interactions between quarks and gluons. And no one's been able to figure out why.

Until now, perhaps, if the new model turns out to be correct.

The solution?

The SMASH model builds on one proposed by physicist Mikhail Shaposhnikov from the Swiss Federal Institute of Technology in Lausanne back in 2005, called the neutrino minimal standard model (or vMSM).

Back then, it was suggested that the extension of the Standard Model by three right-handed neutrinos with certain masses could simultaneously explain the dark matter and baryon asymmetry of the Universe, while also being consistent with the experiments on neutrino oscillations.

Now, the team led by French physicist Guillermo Ballesteros from the University of Paris-Saclay says we can add these three right-handed neutrinos to the three existing neutrinos in the standard model, plus a subatomic particle called a colour triplet fermion, to solve the first four problems listed above.

The addition of a new, unidentified field appears to take care of the fifth problem, as Shannon Hall explains for New Scientist: "SMASH adds a new field to explain some of those problems a little differently. This field includes two particles: the axion, a dark horse candidate for dark matter, and the inflaton, the particle behind inflation.

As a final flourish, SMASH uses the field to introduce the solution to a fifth puzzle: the strong CP problem."

The team says the fact that their hypothesis could be tested using the next generation of particle accelerators means it's not out of the realm of possibility, and that makes it more convincing than other solutions to these problems that have been proposed in the past.

"The best thing about the theory is that it can be tested or checked within the next 10 years or so," one of the team, Andreas Ringwald from the German Electron Synchrotron, told Hall.

"You can always invent new theories, but if they can only be tested in 100 years, or never, then this is not real science but meta-science."

It should be noted that the SMASH model has yet to be published in a peer-reviewed journal, so it still needs to undergo the scrutiny of the particle physics world, but it's now up on pre-print website arXiv.org, so independent physicists have the chance to do just that.

This probably won't end up being the final solution to the 'five big questions' - physics is never that clean-cut - but it could be the beginning of something awesome.

As Ringwald says, "The battle is open." [17]

The secret lives of long-lived particles

The universe is unbalanced. Gravity is tremendously weak. But the weak force, which allows particles to interact and transform, is enormously strong. The mass of the Higgs boson is suspiciously petite. And the catalog of the makeup of the cosmos? Ninety-six percent incomplete.

Almost every observation of the subatomic universe can be explained by the Standard Model of particle physics—a robust theoretical framework bursting with verifiable predictions. But because of these unsolved puzzles, the math is awkward, incomplete and filled with restrictions.

A few more particles would solve almost all of these frustrations. Supersymmetry (nicknamed SUSY for short) is a colossal model that introduces new particles into the Standard Model's equations. It rounds out the math and ties up loose ends. The only problem is that after decades of searching, physicists have found none of these new friends.

But maybe the reason physicists haven't found SUSY (or other physics beyond the Standard Model) is because they've been looking through the wrong lens.

"Beautiful sets of models keep getting ruled out," says Jessie Shelton, a theorist at the University of Illinois, "so we've had to take a step back and consider a whole new dimension in our searches, which is the lifetime of these particles."

In the past, physicists assumed that new particles produced in particle collisions would decay immediately, almost precisely at their points of origin. Scientists can catch particles that behave this way—for example, Higgs bosons—in particle detectors built around particle collision points. But what if new particles had long lifetimes and traveled centimeters—even kilometers—before transforming into something physicists could detect?

This is not unprecedented. Bottom quarks, for instance, can travel a few tenths of a millimeter before decaying into more stable particles. And muons can travel several kilometers (with the help of special relativity) before transforming into electrons and neutrinos. Many theorists are now predicting that there may be clandestine species of particles that behave in a similar fashion. The only catch is that these long-lived particles must rarely interact with ordinary matter, thus explaining why they've escaped detection for so long. One possible explanation for this aloof behavior is that long-lived particles dwell in a hidden sector of physics.

"Hidden-sector particles are separated from ordinary matter by a quantum mechanical energy barrier—like two villages separated by a mountain range," says Henry Lubatti from the University of Washington. "They can be right next to each other, but without a huge boost in energy to get over the peak, they'll never be able to interact with each other."

High-energy collisions generated by the Large Hadron Collider could kick these hidden-sector particles over this energy barrier into our own regime. And if the LHC can produce them, scientists should be able to see the fingerprints of long-lived particles imprinted in their data.

Long-lived particles jolted into our world by the LHC would most likely fly at close to the speed of light for between a few micrometers and a few hundred thousand kilometers before transforming into ordinary and measurable matter. This incredibly generous range makes it difficult for scientists to pin down where and how to look for them.

But the lifetime of a subatomic particle is much like that of any living creature. Each type of particle has an average lifespan, but the exact lifetime of an individual particle varies. If these long-lived particles can travel thousands of kilometers before decaying, scientists are hoping that they'll still be able to catch a few of the unlucky early-transformers before they leave the detector. Lubatti and his collaborators have also proposed a new LHC surface detector, which would extend their search range by many orders of magnitude.

Because these long-lived particles themselves don't interact with the detector, their signal would look like a stream of ordinary matter spontaneously appearing out of nowhere.

"For instance, if a long lived particle decayed into quarks while inside the muon detector, it would mimic the appearance of several muons closely clustered together," Lubatti says. "We are triggering on events like this in the ATLAS experiment." After recording the events, scientists use custom algorithms to reconstruct the origins of these clustered particles to see if they could be the offspring of an invisible long-lived parent.

If discovered, this new breed of matter could help answer several lingering questions in physics.

"Long-lived particles are not a prediction of a single new theory, but rather a phenomenon that could fit into almost all of our frameworks for beyond-the-Standard-Model physics," Shelton says.

In addition to rounding out the Standard Model's mathematics, inert long-lived particles could be cousins of dark matter—an invisible form of matter that only interacts with the visible cosmos through gravity. They could also help explain the origin of matter after the Big Bang.

"So many of us have spent a lifetime studying such a tiny fraction of the universe," Lubatti says. "We've understood a lot, but there's still a lot we don't understand—an enormous amount we don't understand. This gives me and my colleagues pause." [16]

Looking for charming asymmetries

One of the biggest challenges in physics is to understand why everything we see in our universe seems to be formed only of matter, whereas the Big Bang should have created equal amounts of matter and antimatter.

CERN's LHCb experiment is one of the best hopes for physicists looking to solve this longstanding mystery.

At the VIII International Workshop on Charm Physics , which took place in Bologna earlier this month, the LHCb Collaboration presented the most precise measurement to date of a phenomenon called Charge-Parity (CP) violation among particles that contain a charm quark.

CP symmetry states that laws of physics are the same if a particle is interchanged with its anti-particle (the "C" part) and if its spatial coordinates are inverted (P). The violation of this symmetry in the first few moments of the universe is one of the fundamental ingredients to explain the apparent cosmic imbalance in favour of matter.

Until now, the amount of CP violation detected among elementary particles can only explain a tiny fraction of the observed matter-antimatter asymmetry. Physicists are therefore extending their search in the quest to identify the source of the missing anti-matter.

The LHCb collaboration made a precise comparison between the decay lifetime of a particle called a D0 meson (formed by a charm quark and an up antiquark) and its anti-matter counterpart D-0 (formed by an charm antiquark and up quark), when decaying either to a pair of pions or a pair of kaons. Any difference in these lifetimes would provide strong evidence that an additional source of CP violation is at work. Although CP violation has been observed in processes involving numerous particles that contain b and s quarks, the effect is still unobserved in the charm-quark sector and its magnitude is predicted to be very small in the Standard Model.

Thanks to the excellent performance of CERN's Large Hadron Collider, for the first time the LHCb collaboration is accumulating a dataset large enough to access the required level of precision on CP-violating effects in charm-meson decays. The latest results indicate that the lifetimes of the D0 and D-0 particles, measured using their decays to pions or kaons, are still consistent, thereby demonstrating that any CP violation effect that is present must indeed be at a tiny level.

However, with many more analyses and data to come, LHCb is looking forward to delving even deeper into the possibility of CP violation in the charm sector and thus closing in on the universe's missing antimatter. "The unique capabilities of our experiment, and the huge production rate of charm mesons at the LHC, allow us to perform measurements that are far beyond the sensitivity of any previous facility," says Guy Wilkinson, spokesperson for the LHCb collaboration. "However, nature demands that we dig even deeper in order to uncover an effect. With the data still to come, we are confident of responding to this challenge," he adds. [15]

Scientists discover how to turn light into matter after 80-year quest

In just one day over several cups of coffee in a tiny office in Imperial's Blackett Physics Laboratory, three physicists worked out a relatively simple way to physically prove a theory first devised by scientists Breit and Wheeler in 1934.

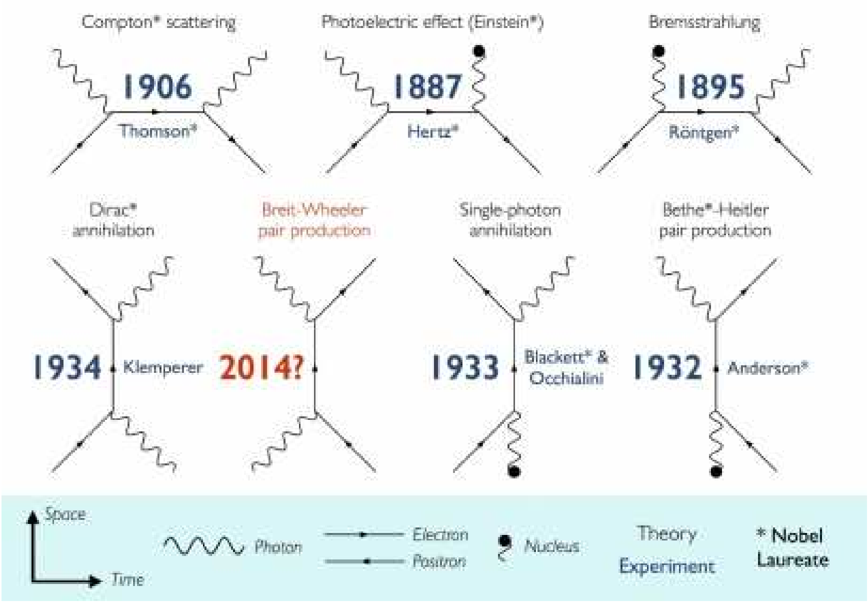
Breit and Wheeler suggested that it should be possible to turn light into matter by smashing together only two particles of light (photons), to create an electron and a positron – the simplest method of turning light into matter ever predicted. The calculation was found to be theoretically sound but Breit and Wheeler said that they never expected anybody to physically demonstrate their prediction. It has never been observed in the laboratory and past experiments to test it have required the addition of massive high-energy particles.

What was so surprising to us was the discovery of how we can create matter directly from light using the technology that we have today in the UK. – Professor Steve Rose Department of Physics

The new research, published in Nature Photonics, shows for the first time how Breit and Wheeler's theory could be proven in practice. This 'photon-photon collider', which would convert light directly into matter using technology that is already available, would be a new type of high-energy physics experiment. This experiment would recreate a process that was important in the first 100 seconds of the universe and that is also seen in gamma ray bursts, which are the biggest explosions in the universe and one of physics' greatest unsolved mysteries.

The scientists had been investigating unrelated problems in fusion energy when they realized what they were working on could be applied to the Breit-Wheeler theory. The breakthrough was achieved in collaboration with a fellow theoretical physicist from the Max Planck Institute for Nuclear Physics, who happened to be visiting Imperial.

Demonstrating the Breit-Wheeler theory would provide the final jigsaw piece of a physics puzzle which describes the simplest ways in which light and matter interact (see image). The six other pieces in that puzzle, including Dirac's 1930 theory on the annihilation of electrons and positrons and Einstein's 1905 theory on the photoelectric effect, are all associated with Nobel Prize-winning research (see image).



Theories describing light and matter interactions. Credit: Oliver Pike, Imperial College London

Professor Steve Rose from the Department of Physics at Imperial College London said: “Despite all physicists accepting the theory to be true, when Breit and Wheeler first proposed the theory, they said that they never expected it be shown in the laboratory. Today, nearly 80 years later, we prove them wrong. What was so surprising to us was the discovery of how we can create matter directly from light using the technology that we have today in the UK. As we are theorists we are now talking to others who can use our ideas to undertake this landmark experiment.”

Within a few hours of looking for applications of hohlraums outside their traditional role in fusion energy research, we were astonished to find they provided the perfect conditions for creating a photon collider. The race to carry out and complete the experiment is on! – Oliver Pike Department of Physics

The collider experiment that the scientists have proposed involves two key steps. First, the scientists would use an extremely powerful high-intensity laser to speed up electrons to just below the speed of light. They would then fire these electrons into a slab of gold to create a beam of photons a billion times more energetic than visible light.

The next stage of the experiment involves a tiny gold can called a hohlraum (German for ‘empty room’). Scientists would fire a high-energy laser at the inner surface of this gold can, to create a thermal radiation field, generating light similar to the light emitted by stars.

They would then direct the photon beam from the first stage of the experiment through the centre of the can, causing the photons from the two sources to collide and form electrons and positrons. It would then be possible to detect the formation of the electrons and positrons when they exited the can. [14]

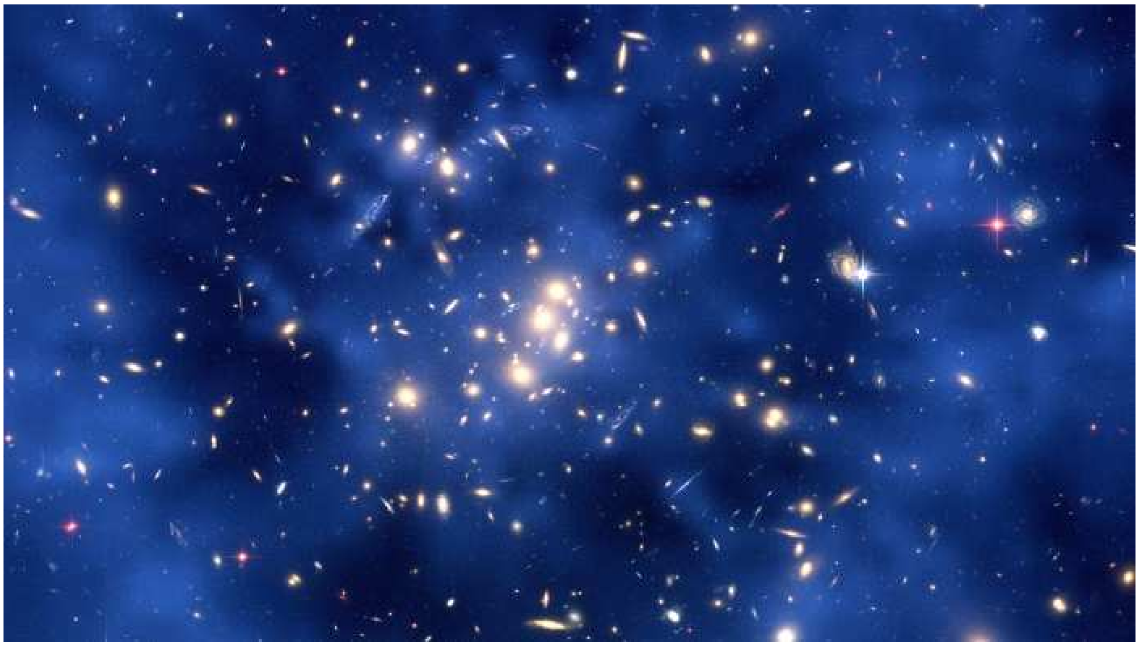
Even If LHC Discovers New Undetectable Particles, Are They Really Dark Matter Particles?

How can the LHC experiments prove that they have produced dark matter? They can't… not alone, anyway. Even if they have made a new type of undetectable particle, they will have to partner with at least one other experiment that can directly check whether the dark matter itself — the stuff found abundantly in the universe — is actually made from LHC's new particles. Simply knowing that the type of particle exists doesn't prove that it makes up most of the matter in the universe. Just like neutrinos, it might make up only a small amount of the matter in the universe. Or it might even make up none, if the new particles are unstable (as is the case for most types of particles), and have a lifetime long enough to travel out of the LHC detectors unseen before they decay, but short enough that they disappeared from the universe shortly after the Big Bang.

To say it more succinctly: even if the LHC makes and discovers a new class of undetectable particles, there's no way for LHC experimenters to figure out how many of these particles, if any, remain in the universe today. The LHC is the wrong machine for that purpose.

So what's to be done? Well, the LHC can be used to figure out some of the properties of the new particles, subject to some assumptions (which can be tested later.) For instance, in the previous section I gave you three examples (and there are many more) of how new undetectable particles could be discovered. In each case, the new particles were produced in a distinct and distinctive way, and other particles accompanied them that gave an indication as to how they were produced. For instance, if the new particles were produced alone, discovery occurred in collisions that made a single recoiling jet. If they were produced in Higgs decays, discovery could occur in events with two high-energy jets from two distinctive quarks. If they were produced in the decay of a new charged particle, discovery could occur in events with a charged lepton and a charged anti-lepton (charged lepton = electron, muon or tau.) So by looking at what accompanies the new particles, and going even deeper into the details of how much missing transverse momentum is typically produced, scientists can potentially begin to put together one or more hypotheses regarding the nature of these new particles. Those hypotheses will be put into the form of equations, which can be used to make predictions. [13]

Seeing dark matter without seeing



Scientists know that dark matter exists because it has a gravitational effect on visible objects made of ordinary matter. And they know that there is a lot of it; dark matter is thought to be about five times as prevalent as other matter in the universe. Yet, dark matter has managed to evade detection so far.

Similar to normal matter, dark matter is commonly believed to be composed of particles. Scientists' current best guess is that these particles are WIMPs: weakly interacting massive particles. These particles would pass right through ordinary matter. That's because they would interact only through the weak nuclear force—which works only over short distances—and gravity.

Scientists are trying to create WIMPs in collisions at the Large Hadron Collider. But it could be that they are too massive to produce in such an accelerator. Scientists are also trying to find WIMPs with detectors deep underground. But so far they haven't appeared.

That's why scientists also search for dark matter indirectly—rather than trying to catch the WIMPs themselves, they look for other signs that they're around. These signs could come in the form of extra gamma rays, cosmic rays or neutrinos, or in patterns imprinted on the cosmic microwave background radiation left over from just after the big bang.

Gamma rays in space

It could be that WIMPs are their own antimatter partners. That means that if one dark matter particle meets another dark matter particle, the two could annihilate, leaving behind a host of lighter particles and gamma rays.

It could also be that unstable dark matter particles produce gamma rays as they decay.

Either way, one would expect that an area dense with dark matter would be marked by a higher-than-usual amount of these energetic rays. Many recent studies claim to have found hints of the existence of dark matter in gamma rays, but not all scientists are convinced.

One area that should be dense with dark matter is the center of our own galaxy, the Milky Way. That's where scientists are looking for excess gamma rays using the Large Area Telescope on NASA's Fermi Gamma-ray Space Telescope spacecraft, which has been orbiting the Earth since 2008.

Last year, the Fermi-LAT collaboration reported its latest analysis of the galactic center, in which the scientists saw a gamma-ray excess similar to other groups before. However, the researchers have not ruled out interpretations due to sources other than dark matter.

The center of the galaxy is an extremely complex region, says Fermi-LAT researcher Troy Porter of the Kavli Institute for Particle Astrophysics and Cosmology, a joint institute of Stanford University and SLAC National Accelerator Laboratory.

"The galactic center is very active and it contains many different gamma-ray sources, some of which we don't even know yet," he says. "In order to be able to identify any potential dark matter signal, we must first know the level of gamma rays from all other possible sources very precisely."

Other locations to search for dark matter signals are dwarf satellite galaxies that orbit the Milky Way, says Fermi-LAT researcher Matthew Wood at KIPAC, who was the co-leader of two recent analyses of 15 known dwarf galaxies and eight new dwarf galaxy candidates discovered by scientists of the Dark Energy Survey and University of Cambridge in the UK.

"Dwarf galaxies are dominated by dark matter and don't contain any known gamma-ray sources," he says. "These objects, which have more than a million times fewer stars than our own galaxy, are ideal targets for indirect dark matter searches."

In March, researchers from Carnegie Mellon University, Brown University and the University of Cambridge published an analysis claiming to have found excess gamma rays in one of these dwarf galaxy candidates. The Fermi-LAT and DES collaborations, however, found no definitive sign of such an excess.

Gamma rays on Earth

The Fermi-LAT instrument can detect gamma rays with energies of up to several hundred billion electronvolts. However, the gamma rays produced by WIMPs could be even more energetic.

This is where ground-based gamma-ray observatories come in.

"To detect gamma rays with an energy of a trillion electronvolts or larger, we need detectors with a large surface area—larger than what we can possibly accommodate aboard a spacecraft," says physicist Gernot Maier, who leads a group at the German research center DESY that is searching for high-energy gamma rays on the VERITAS experiment in Arizona.

VERITAS, along with MAGIC on the Canary Islands and H.E.S.S. in Namibia, uses an array of telescopes that detect particle showers caused by gamma rays as they travel through the Earth's atmosphere. None of them have spotted signs of dark matter yet.

Next year, a new ground-based gamma-ray observatory will begin construction. The Cherenkov Telescope Array will consist of about 100 telescopes and will be 10 times as sensitive to high-energy gamma rays from dark matter interactions.

Cosmic rays

Cosmic rays are extremely energetic radiation composed of charged particles. Just as dark matter annihilations or decays could produce gamma rays, they could also produce cosmic rays. So an unexplained excess of this type of radiation might point to the presence of dark matter.

This is the way the Alpha Magnetic Spectrometer experiment, run by MIT physicist and Nobel Prize winner Sam Ting, hopes to discover dark matter.

For the past four years, AMS has studied cosmic rays from its perch on the side of the International Space Station.

“So far the data are totally consistent with WIMP annihilations,” Ting says of the AMS measurements of electrons and positrons in cosmic rays.

AMS isn’t the only experiment to spot a possible sign of dark matter in cosmic rays. In 2009, the PAMELA satellite experiment reported a surplus of cosmic-ray positrons—a result that Fermi-LAT researchers confirmed in 2011.

Ting says the AMS collaboration plans to release their next results this month.

Neutrinos from the sun

Dark matter annihilations could also produce almost massless particles called neutrinos.

Experiments that search for signs of dark matter in neutrinos use the sun as a dark matter detector. WIMPs could get gravitationally trapped in the center of the massive star. Once the density of WIMPs there became large enough, they could annihilate and produce neutrinos.

Scientists use observatories such as ANTARES under the Mediterranean Sea, the Lake Baikal Neutrino Telescope in Russia, Super-Kamiokande in Japan and IceCube at the South Pole to look for such an event.

“Only neutrinos are able to escape from the center of the sun,” says IceCube leader Francis Halzen of the University of Wisconsin, Madison. “If we ever find such a high-energy neutrino signal, there will be no debate as to whether we have found a dark matter signature or not.”

Unlike gamma or cosmic rays, which can have several astrophysical origins, high-energy neutrinos emerging from the center of the sun could be produced only in dark matter annihilations.

Caught in the afterglow

The Cosmic Microwave Background is the afterglow of the big bang 14 billion years ago. It exists as a faint pattern of light on the sky. If WIMPs existed in the early universe, they should have left their fingerprint on this radiation.

From 2009 to 2013, the European Space Agency’s Planck space telescope recorded a precise map of this light.

“We measured the dark matter content of the young universe, when it was only 380,000 years old,” says Planck project scientist Jan Tauber.

Planck’s latest publication, released in February, put constraints on the properties of hypothetical WIMPs that are in conflict with the interpretation of positron-excess data from PAMELA, AMS and Fermi-LAT.

Tauber says the Planck collaboration will release more data early next year.

The search goes on

No one knows which method, if any, will lead to the discovery of dark matter. But one thing is clear: Dark matter is quickly losing places to hide. [12]

Best way to measure dark energy just got better

A Type Ia supernova occurs when a white dwarf accretes material from a companion star until it exceeds the Chandrasekhar limit and explodes. By studying these exploding stars, astronomers can measure dark energy and the expansion of the universe. CfA scientists have found a way to correct for small variations in the appearance of these supernovae, so that they become even better standard candles. The key is to sort the supernovae based on their color.

Dark energy is a mysterious force that pervades all space, acting as a "push" to accelerate the Universe's expansion. Despite being 70 percent of the Universe, dark energy was only discovered in

1998 by two teams observing Type Ia supernovae. A Type 1a supernova is a cataclysmic explosion of a white dwarf star.

These supernovae are currently the best way to measure dark energy because they are visible across intergalactic space. Also, they can function as "standard candles" in distant galaxies since the intrinsic brightness is known. Just as drivers estimate the distance to oncoming cars at night from the brightness of their headlights, measuring the apparent brightness of a supernova yields its distance (fainter is farther). Measuring distances tracks the effect of dark energy on the expansion of the Universe.

The best way of measuring dark energy just got better, thanks to a new study of Type Ia supernovae led by Ryan Foley of the Harvard-Smithsonian Center for Astrophysics. He has found a way to correct for small variations in the appearance of these supernovae, so that they become even better standard candles. The key is to sort the supernovae based on their color.

"Dark energy is the biggest mystery in physics and astronomy today. Now, we have a better way to tackle it," said Foley, who is a Clay Fellow at the Center. He presented his findings in a press conference at the 217th meeting of the American Astronomical Society.

The new tool also will help astronomers to firm up the cosmic distance scale by providing more accurate distances to faraway galaxies.

Type Ia supernovae are used as standard candles, meaning they have a known intrinsic brightness. However, they're not all equally bright. Astronomers have to correct for certain variations. In particular, there is a known correlation between how quickly the supernova brightens and dims (its light curve) and the intrinsic peak brightness.

Even when astronomers correct for this effect, their measurements still show some scatter, which leads to inaccuracies when calculating distances and therefore the effects of dark energy. Studies looking for ways to make more accurate corrections have had limited success until now.

"We've been looking for this sort of 'second-order effect' for nearly two decades," said Foley.

Foley discovered that after correcting for how quickly Type Ia supernovae faded, they show a distinct relationship between the speed of their ejected material and their color: the faster ones are slightly redder and the slower ones are bluer.

Previously, astronomers assumed that redder explosions only appeared that way because of intervening dust, which would also dim the explosion and make it appear farther than it was. Trying to correct for this, they would incorrectly calculate that the explosion was closer than it appeared. Foley's work shows that some of the color difference is intrinsic to the supernova itself.

The new study succeeded for two reasons. First, it used a large sample of more than 100 supernovae. More importantly, it went back to "first principles" and reexamined the assumption that Type Ia supernovae are one average color. [11]

The Big Bang

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.

Study Reveals Indications That Dark Matter is Being Erased by Dark Energy

Researchers in Portsmouth and Rome have found hints that dark matter, the cosmic scaffolding on which our Universe is built, is being slowly erased, swallowed up by dark energy.

The findings appear in the journal Physical Review Letters, published by the American Physical Society. In the journal cosmologists at the Universities of Portsmouth and Rome, argue that the latest astronomical data favors a dark energy that grows as it interacts with dark matter, and this appears to be slowing the growth of structure in the cosmos.

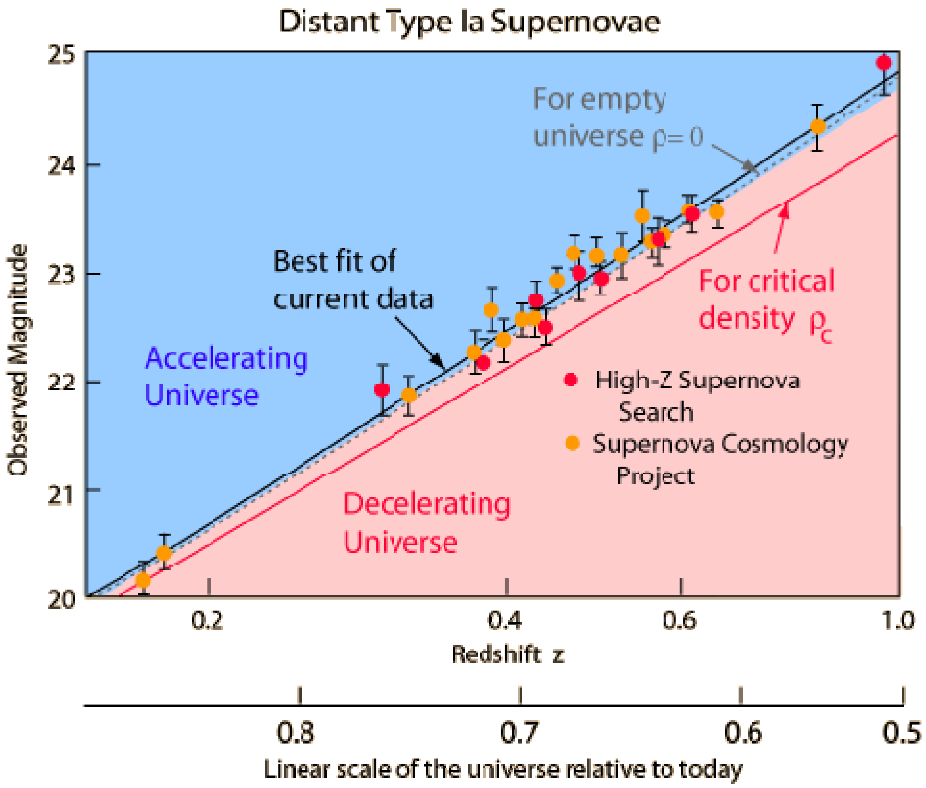
“Dark matter provides a framework for structures to grow in the Universe. The galaxies we see are built on that scaffolding and what we are seeing here, in these findings, suggests that dark matter is evaporating, slowing that growth of structure.”

Cosmology underwent a paradigm shift in 1998 when researchers announced that the rate at which the Universe was expanding was accelerating. The idea of a constant dark energy throughout space-time (the “cosmological constant”) became the standard model of cosmology, but now the Portsmouth and Rome researchers believe they have found a better description, including energy transfer between dark energy and dark matter. [10]

Evidence for an accelerating universe

One of the observational foundations for the big bang model of cosmology was the observed expansion of the universe. [9] Measurement of the expansion rate is a critical part of the study, and it has been found that the expansion rate is very nearly "flat". That is, the universe is very close to the critical density, above which it would slow down and collapse inward toward a future "big crunch". One of the great challenges of astronomy and astrophysics is distance measurement over the vast distances of the universe. Since the 1990s it has become apparent that type Ia supernovae offer a unique opportunity for the consistent measurement of distance out to perhaps 1000 Mpc. Measurement at these great distances provided the first data to suggest that the expansion rate of the universe is actually accelerating. That acceleration implies an energy density that acts in opposition to gravity which would cause the expansion to accelerate. This is an energy density which we have not directly detected observationally and it has been given the name "dark energy".

The type Ia supernova evidence for an accelerated universe has been discussed by Perlmutter and the diagram below follows his illustration in Physics Today.



The data summarized in the illustration above involve the measurement of the redshifts of the distant supernovae. The observed magnitudes are plotted against the redshift parameter z. Note that there are a number of Type 1a supernovae around z=.6, which with a Hubble constant of 71 km/s/mpc is a distance of about 5 billion light years.

Equation

The cosmological constant Λ appears in Einstein's field equation [5] in the form of

$$R_{\mu\nu} - \frac{1}{2}R\,g_{\mu\nu} + \Lambda\,g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}\,,$$

where *R* and *g* describe the structure of spacetime, *T* pertains to matter and energy affecting that structure, and *G* and *c* are conversion factors that arise from using traditional units of measurement.

When Λ is zero, this reduces to the original field equation of general relativity. When *T* is zero, the field equation describes empty space (the vacuum).

The cosmological constant has the same effect as an intrinsic energy density of the vacuum, ρ_{vac} (and an associated pressure). In this context it is commonly moved onto the right-hand side of the equation, and defined with a proportionality factor of 8π: $\Lambda = 8\pi\rho_{vac}$, where unit conventions of general relativity are used (otherwise factors of *G* and *c* would also appear). It is common to quote values of energy density directly, though still using the name "cosmological constant".

A positive vacuum energy density resulting from a cosmological constant implies a negative pressure, and vice versa. If the energy density is positive, the associated negative pressure will drive an accelerated expansion of the universe, as observed. (See dark energy and cosmic inflation for details.)

Explanatory models

Models attempting to explain accelerating expansion include some form of dark energy, dark fluid or phantom energy. The most important property of dark energy is that it has negative pressure which is distributed relatively homogeneously in space. The simplest explanation for dark energy is that it is a cosmological constant or vacuum energy; this leads to the Lambda-CDM model, which is generally known as the Standard Model of Cosmology as of 2003-2013, since it is the simplest model in good agreement with a variety of recent observations.

Dark Matter and Energy

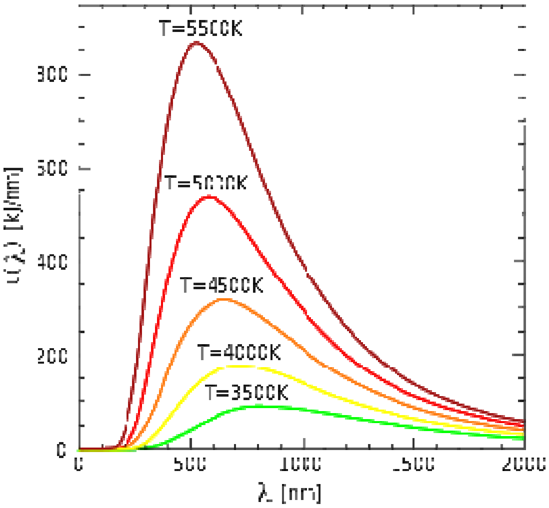
Dark matter is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant level. It is otherwise hypothesized to simply be matter that is not reactant to light. Instead, the existence and properties of dark matter are inferred from its gravitational effects on visible matter, radiation, and the large-scale structure of the universe. According to the Planck mission team, and based on the standard model of cosmology, the total mass–energy of the known universe contains 4.9% ordinary matter, 26.8% dark matter and 68.3% dark energy. Thus, dark matter is estimated to constitute 84.5% of the total matter in the universe, while dark energy plus dark matter constitute 95.1% of the total content of the universe. [6]

Cosmic microwave background

The cosmic microwave background (CMB) is the thermal radiation assumed to be left over from the "Big Bang" of cosmology. When the universe cooled enough, protons and electrons combined to form neutral atoms. These atoms could no longer absorb the thermal radiation, and so the universe became transparent instead of being an opaque fog. [7]

Thermal radiation

Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter. All matter with a temperature greater than absolute zero emits thermal radiation. When the temperature of the body is greater than absolute zero, interatomic collisions cause the kinetic energy of the atoms or molecules to change. This results in charge-acceleration and/or dipole oscillation which produces electromagnetic radiation, and the wide spectrum of radiation reflects the wide spectrum of energies and accelerations that occur even at a single temperature. [8]



Electromagnetic Field and Quantum Theory

Needless to say that the accelerating electrons of the steady stationary current are a simple demystification of the magnetic field, by creating a decreasing charge distribution along the wire, maintaining the decreasing U potential and creating the **A** vector potential experienced by the electrons moving by **v** velocity relative to the wire. This way it is easier to understand also the time dependent changes of the electric current and the electromagnetic waves as the resulting fields moving by c velocity.

It could be possible something very important law of the nature behind the self maintaining **E** accelerating force by the accelerated electrons. The accelerated electrons created electromagnetic fields are so natural that they occur as electromagnetic waves traveling with velocity c. It shows that the electric charges are the result of the electromagnetic waves diffraction.

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. [4]

Lorentz transformation of the Special Relativity

In the referential frame of the accelerating electrons the charge density lowering linearly because of the linearly growing way they takes every next time period. From the referential frame of the wire there is a parabolic charge density lowering.

The difference between these two referential frames, namely the referential frame of the wire and the referential frame of the moving electrons gives the relativistic effect. Important to say that the moving electrons presenting the time coordinate, since the electrons are taking linearly increasing way every next time period, and the wire presenting the geometric coordinate. The Lorentz transformations are based on moving light sources of the Michelson - Morley experiment giving a practical method to transform time and geometric coordinates without explaining the source of this mystery.

The real mystery is that the accelerating charges are maintaining the accelerating force with their charge distribution locally. The resolution of this mystery that the charges are simply the results of the diffraction patterns, that is the charges and the electric field are two sides of the same thing. Otherwise the charges could exceed the velocity of the electromagnetic field.

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 Classical Relativistic effect

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.

Electromagnetic inertia and Gravitational attraction

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.

It looks clear that the growing acceleration results the relativistic growing mass - limited also with the velocity of the electromagnetic wave.

Since $E = h\nu$ and $E = mc^2$, $m = h\nu / c^2$ that is the m depends only on the ν 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.

If the mass is electromagnetic, then the gravitation is also electromagnetic effect caused by the accelerating Universe! The same charges would attract each other if they are moving parallel by the magnetic effect.

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.

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

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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. [1]

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 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. [2]

Dark Matter and Plank Distribution Law

The Ultraviolet Catastrophe resolved by the Planck Distribution Law, but born a new problem of the Dark Matter and Energy. Part of the UV radiation has no compensating Infrared radiation on the same intensity level giving diffraction patterns that is real matter constructions. Increasing the temperature increases the uncompensated UV radiation so it looks like there is a weak interaction changing the charge distribution between the diffraction sides of the Planck curve. This gives the idea of WIMP and the Sterile Neutrinos, thinking also about chunks of Dark Matter. Since charge is not moving from one side of the diffraction pattern to the other side it could not be weak interaction. Since matter is disappearing with the increasing temperature we could think about annihilation of matter involving also anti matter. It is happening on the peak of the Planck curve but not on the sides of the UV and Infrared oscillation. This means that there is a matter to energy conversation with the increasing temperature. Of course there would be new diffraction patterns also on higher temperature and we would be seen in the LHC some new diffraction patterns, but surely no Dark Matter and of course more Dark Energy.

Conclusions

Lead researcher Oliver Pike who is currently completing his PhD in plasma physics, said: "Although the theory is conceptually simple, it has been very difficult to verify experimentally. We were able to develop the idea for the collider very quickly, but the experimental design we propose can be carried out with relative ease and with existing technology. Within a few hours of looking for applications of hohlraums outside their traditional role in fusion energy research, we were astonished to find they provided the perfect conditions for creating a photon collider. The race to carry out and complete the experiment is on!" [14]

No one knows which method, if any, will lead to the discovery of dark matter. But one thing is clear: Dark matter is quickly losing places to hide. [12]

The discovery provides a better physical understanding of Type Ia supernovae and their intrinsic differences. It also will allow cosmologists to improve their data analysis and make better measurements of dark energy -- an important step on the road to learning what this mysterious force truly is, and what it means for the future of the cosmos. [11]

Newly published research reveals that dark matter is being swallowed up by dark energy, offering novel insight into the nature of dark matter and dark energy and what the future of our Universe might be.

The changing temperature of the Universe will change the proportionality of the dark energy and the corresponding dark matter by the Planck Distribution Law, giving the base of this newly published research.

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.

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The electric currents causing self maintaining electric potential is the source of the special and general relativistic effects. The Higgs Field is the result of the electromagnetic induction. The Graviton is two photons together. [3]

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