

Seeing Dark Matter - without seeing

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 Ia 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.

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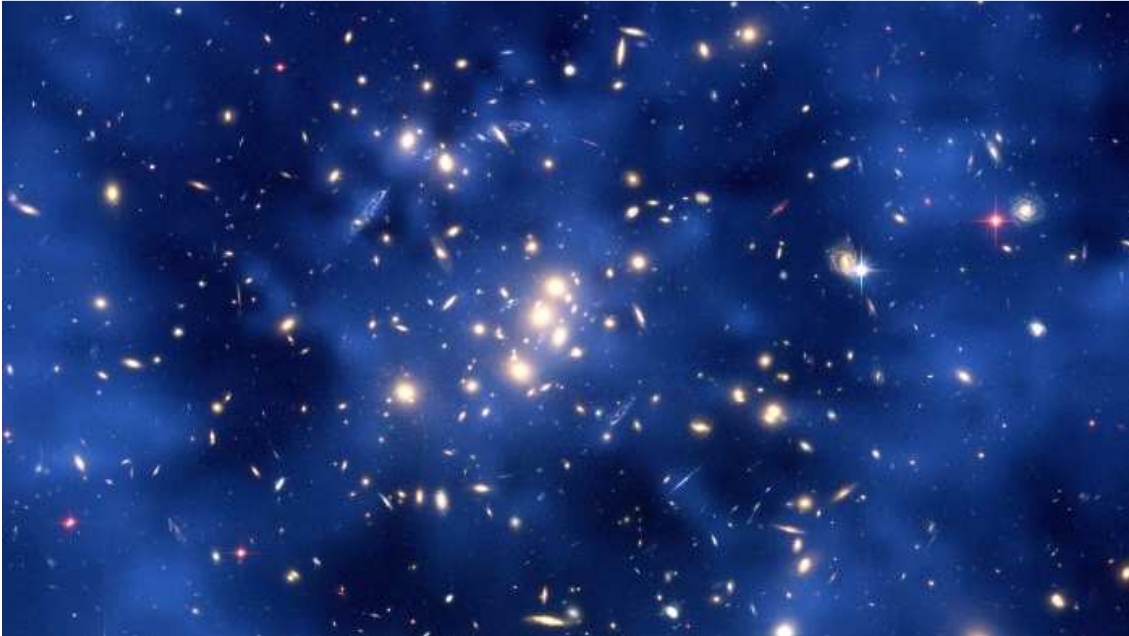
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Seeing dark matter without seeing



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.

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1998 by two teams observing Type Ia supernovae. A Type Ia 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!?

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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.”

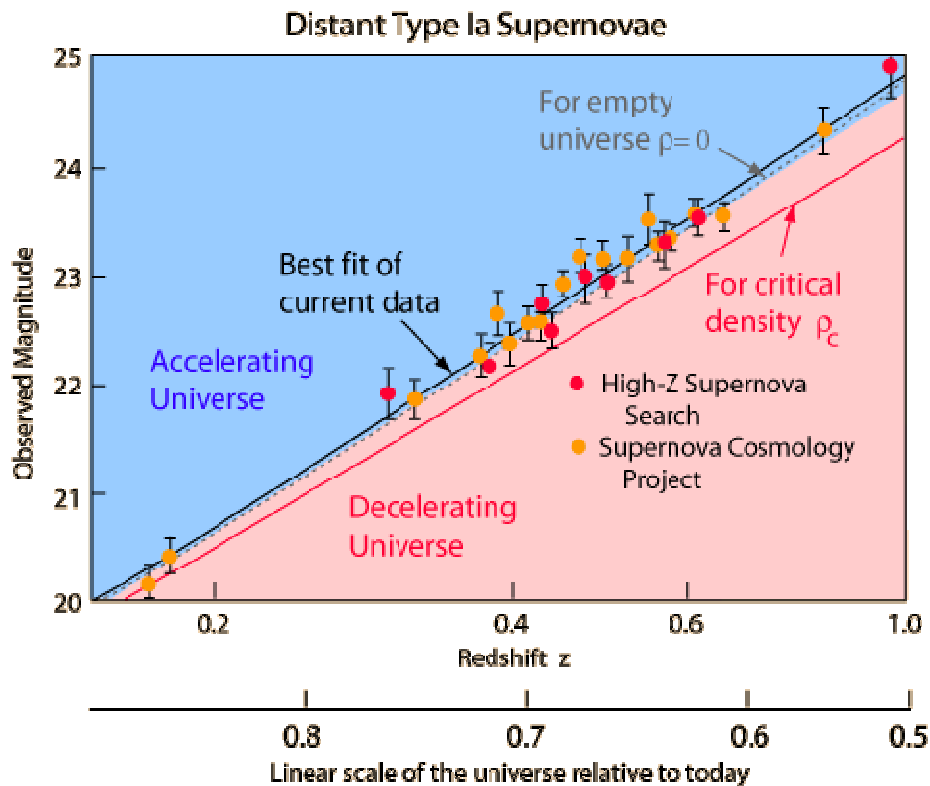
Cosmology underwent a paradigm shift in 1998 when researchers announced that the rate at which the Universe was expanding was accelerating. The idea of a constant dark energy throughout space-time (the “cosmological constant”) became the standard model of cosmology, but now the Portsmouth and Rome researchers 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 Ia supernovae around $z=0.6$, 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

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

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 : $\Lambda = 8\pi\rho_{\text{vac}}$, 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]

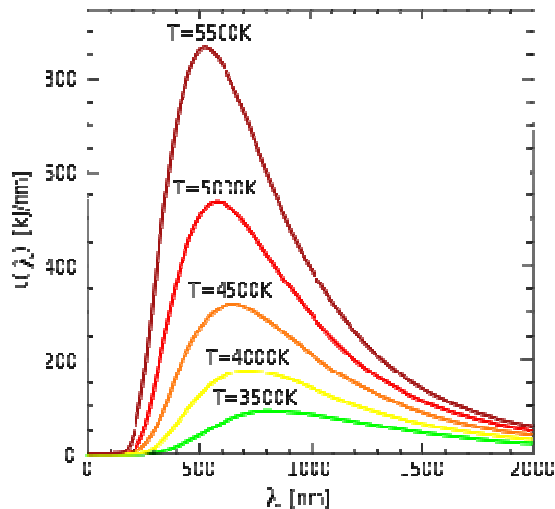
Cosmic microwave background

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 \underline{A} vector potential experienced by the electrons moving by \underline{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 \underline{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_0 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

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Relativistic change of mass

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The frequency dependence of mass

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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 Big 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 ratio $M_p = 1840 M_e$. 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.

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]

Conclusions

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.

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