LUX Dark Matter Experiment

The LUX Dark Matter Experiment operates a mile underground at the Sanford Underground Research Facility. It's location helps shield the detector from background radiation that could confound a dark matter signal. [18]

To address this problem, physicists are working on developing ever more sensitive dark matter detectors. In a new paper, researchers have proposed a new type of dark matter detector made of superconductors—materials that conduct electricity with zero resistance at ultracold temperatures—that may offer the highest sensitivity yet for detecting "superlight" dark matter. Superlight dark matter has a mass at the low end of the range of 1 keV (1000 electron volts) to 10 GeV, or in other words, up to a million times lighter than the proton. [17]

Physicists believe that such dark matter is composed of (as yet undefined) elementary particles that stick together thanks to gravitational force. In a study recently published in EPJ C, scientists from the CRESST-II research project use the so-called phonon-light technique to detect dark matter. [16]

A team of researchers at MIT has succeeded in creating a double film coating that is able to convert infrared light at modest intensities into visible light. In their paper published in the journal Nature Photonics, the team describes their film, how well it works and the possible uses for it. [15]

Before the Hawaii-bound storm Julio strengthened into a hurricane, a NASA satellite spotted a high-energy flash of "dark lightning" coming from the swirling clouds. [14]

Researchers may have uncovered a way to observe dark matter thanks to a discovery involving X-ray emissions. [13]

Between 2009 and 2013, the Planck satellite observed relic radiation, sometimes called cosmic microwave background (CMB) radiation. Today, with a full analysis of the data, the quality of the map is now such that the imprints left by dark matter and relic neutrinos are clearly visible. [12]

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

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

The Weak Interaction changes the temperature dependent Planck Distribution of the electromagnetic oscillations and changing the non-compensated dark matter rate, giving the responsibility to the sterile neutrino.

Contents

Author: George Rajna

World's most sensitive dark matter detector completes search

The Large Underground Xenon (LUX) dark matter experiment, which operates beneath a mile of rock at the Sanford Underground Research Facility in the Black Hills of South Dakota, has completed its silent search for the missing matter of the universe.

Today at an international dark matter conference (IDM 2016) in Sheffield, U.K., LUX scientific collaborators presented the results from the detector's final 20-month run from October 2014 to May 2016. The new research result is also described with further details on the LUX Collaboration's website.

LUX's sensitivity far exceeded the goals for the project, collaboration scientists said, but yielded no trace of a dark matter particle. LUX's extreme sensitivity makes the team confident that if dark matter particles had interacted with the LUX's xenon target, the detector would almost certainly have seen it. That enables scientists to confidently eliminate many potential models for dark matter particles, offering critical guidance for the next generation of dark matter experiments.

"LUX has delivered the world's best search sensitivity since its first run in 2013," said Rick Gaitskell, professor of physics at Brown University and co-spokesperson for the LUX experiment. "With this final result from the 2014 to 2016 search, the scientists of the LUX Collaboration have pushed the sensitivity of the instrument to a final performance level that is four times better than the original project goals. It would have been marvelous if the improved sensitivity had also delivered a clear dark matter signal. However, what we have observed is consistent with background alone."

Dark matter is thought to account for more than four-fifths of the mass in the universe. Scientists are confident of its existence because the effects of its gravity can be seen in the rotation of galaxies and in the way light bends as it travels through the universe, but experiments have yet to make direct contact with a dark matter particle. The LUX experiment was designed to look for weakly interacting massive particles, or WIMPs, the leading theoretical candidate for a dark matter particle.

If the WIMP idea is correct, billions of these particles pass through your hand every second, and also through the Earth and everything on it. But because WIMPs interact so weakly with ordinary matter, this ghostly traverse goes entirely unnoticed.

The LUX detector consists of a third-of-a-ton of cooled liquid xenon surrounded by powerful sensors designed to detect the tiny flash of light and electrical charge emitted if a WIMP collides with a xenon atom within the tank. The detector's location at Sanford Lab beneath a mile of rock, and inside a 72,000-gallon, high-purity water tank, helps shield it from cosmic rays and other radiation that would interfere with a dark matter signal.

The 20-month run of LUX represents one of the largest exposures ever collected by a dark matter experiment, the researchers said. The rapid analysis of nearly a half-million gigabytes of data produced over 20 months was made possible by the use of more than 1,000 computer nodes at Brown University's Center for Computation and Visualization and the advanced computer simulations at Lawrence Berkeley National Laboratory's National Energy Research Scientific Computing Center.

Careful calibration

The exquisite sensitivity achieved by the LUX experiment came thanks to a series of pioneering calibration measures aimed at helping scientists tell the difference between a dark matter signal and events created by residual background radiation that even the elaborate construction of the experiment cannot completely block out.

"As the charge and light signal response of the LUX experiment varied slightly over the dark matter search period, our calibrations allowed us to consistently reject radioactive backgrounds, maintain a well-defined dark matter signature for which to search and compensate for a small static charge buildup on the Teflon inner detector walls," said Dan McKinsey, professor of physics at the University of California, Berkeley, senior faculty scientist at Lawrence Berkeley National Laboratory, and co-spokesperson for the LUX experiment.

One calibration technique used neutrons as stand-ins for WIMPs. By firing a beam of neutrons into the detector, scientists were able to carefully quantify how the LUX detector responds to the signal expected to be produced from a WIMP collision. Other calibration techniques involved injecting radioactive gases into the detector to help distinguish between signals produced by ambient radioactivity and a potential dark matter signal.

These calibration measures, used for the first time with LUX, helped scientists meticulously search through a wide swath of potential parameter space for dark matter particles.

"These careful background-reduction techniques and precision calibrations and modeling have enabled us to probe dark matter candidates that would produce signals of only a few events per century in a kilogram of xenon," said Aaron Manalaysay, the analysis working group coordinator of the LUX experiment and a research scientist from the University of California, Davis, who presented the new results in Sheffield.

"We worked hard and stayed diligent over more than a year and a half to keep the detector running in optimal conditions and maximize useful data time," said Simon Fiorucci, physicist at Lawrence Berkeley National Laboratory and science coordination manager for the experiment. "The result is unambiguous data we can be proud of and a timely result in this very competitive field—even if it is not the positive detection we were all hoping for."

The quest continues

While the LUX experiment successfully eliminated a large swath of mass ranges and interaction-coupling strengths where WIMPs might exist, the WIMP model itself, "remains alive and viable," said Gaitskell, the Brown University physicist. And the meticulous work of LUX scientists will aid future direct detection experiments.

"We viewed this as a David and Goliath race between ourselves and the much larger Large Hadron Collider (LHC) at CERN in Geneva," Gaitskell said. "LUX was racing over the last three years to get first evidence for a dark matter signal. We will now have to wait and see if the new run this year at the LHC will show evidence of dark matter particles, or if the discovery occurs in the next generation of larger direct detectors."

Among those next generation experiments will be the LUX-ZEPLIN (LZ) experiment, which will replace LUX at the Sanford Underground Research Facility.

Compared to LUX's one-third-ton of liquid xenon, LZ will have a 10-ton liquid xenon target, which will fit inside the same 72,000-gallon tank of pure water used by LUX to help fend off external radiation.

"The innovations of the LUX experiment form the foundation for the LZ experiment," said Harry Nelson, University of California, Santa Barbara, and spokesperson for LZ. "We expect LZ to achieve 70 times the sensitivity of LUX. The LZ program continues to pass its milestones, aided by the terrific support of the Sanford Lab, the Department of Energy and its many collaborating institutions and scientists. LZ should be online in 2020."

LUX, the first major astrophysics experiment in the Davis Campus of the Sanford Underground Research Facility (Sanford Lab), was installed in 2012. Sanford Lab is located in the former Homestake Gold Mine in Lead, S.D. A South Dakota-owned facility, it is managed by the South Dakota Science and Technology Authority (SDSTA), which reopened the mine in 2007 with $40 million in funding from the South Dakota State Legislature and a $70 million donation from philanthropist T. Denny Sanford. The U.S. Department of Energy (DOE) supports Sanford Lab's operations.

"The global search for dark matter aims to answer fundamental questions about the makeup of our universe. We're proud to support the LUX collaboration and congratulate them on reaching this higher level of sensitivity," said Mike Headley, executive director of the SDSTA. "We're looking forward to hosting the LUX-ZEPLIN (LZ) experiment, which will provide another major step forward in sensitivity."

The LUX scientific collaboration, which is supported by the DOE and National Science Foundation, includes 20 research universities and national laboratories in the United States, the United Kingdom and Portugal.

Over the next few months, LUX scientists will continue to analyze the crucial data that LUX was able to provide, in hopes of helping future experiments finally pin down a dark matter particle.

"LUX has done much more in terms of its sensitivity and reliability than we ever expected it to do," Gaitskell said. "We always want more time with our detectors, but it's time to take the lessons learned from LUX and apply them to the future search for dark matter." [18]

Superconductors could detect superlight dark matter

Many experiments are currently searching for dark matter—the invisible substance that scientists know exists only from its gravitational effect on stars, galaxies, and other objects made of ordinary matter. On Earth, scientists are using particle accelerators such as the Large Hadron Collider (LHC) to search for dark matter, while keeping an eye out elsewhere with detectors in space and even detectors located thousands of feet underground. Although scientists have covered all of their bases location-wise, these detectors may not be sensitive enough to detect dark matter if the mass of the dark matter is less than about 10 GeV (10 billion electron volts).

To address this problem, physicists are working on developing ever more sensitive dark matter detectors. In a new paper, researchers have proposed a new type of dark matter detector made of superconductors—materials that conduct electricity with zero resistance at ultracold temperatures—that may offer the highest sensitivity yet for detecting "superlight" dark matter. Superlight dark matter has a mass at the low end of the range of 1 keV (1000 electron volts) to 10 GeV, or in other words, up to a million times lighter than the proton.

The physicists, Yonit Hochberg and Kathryn M. Zurek at Lawrence Berkeley National Laboratory and the University of California, Berkeley, and Yue Zhao at Stanford University (now at the University of Michigan), have published a paper on the superconducting detectors in a recent issue of Physical Review Letters.

"The greatest significance of our work is the potential ability to detect dark matter with mass between a thousand to a million times lighter than the mass of the proton," Zurek told Phys.org. "Current dark matter direct detection experiments and other proposed methods are not sensitive to such light dark matter.
Superconducting detectors are the only (proposed) game in town for dark matter in this mass range."

Although most of the time dark matter does not interact with anything, scientists have to assume it interacts with ordinary matter somehow, or else they could not detect it in the lab. But it's unclear whether dark matter interacts with electrons, nuclei, both, or something else.

In general, dark matter detectors are based on the principle that, if a dark matter particle were to hit the detector and interact with it, the collision would produce another type of particle such as a photon or phonon (a quanta of vibration) at a specific energy. The detector material is extremely important, as the interaction between dark matter and the detector determines the specific properties of the particle that is produced. Some of the most highly sensitive detectors today are made of liquid xenon (LZ detector), germanium crystal (SuperCDMS), and other similar materials.

In the new paper, the physicists showed that a dark matter detector made out of a superconducting material, such as ultrapure aluminum, could be the most sensitive material yet, capable of detecting dark matter with a mass of a few hundred keV or less. The sensitivity arises from the fact that superconductors have a zero or near-zero band gap, which is the energy gap that electrons must cross to allow a material to conduct electricity. Aluminum, for example, has a tiny band gap of 0.3 meV (0.0003 eV).

"Superconducting detectors are more sensitive than other detectors due to their tiny energy gap," Hochberg said. "This tiny gap means that they are sensitive to very small energy depositions, which in turn means that they are sensitive to very light dark matter masses, down to a million times lighter than the proton. This is in contrast to, for example, standard semiconductors, which (due to their thousand-times-larger band gap) can be sensitive to dark matter only down to a thousand times lighter than the proton."

The idea is that one of the dark matter particles that are thought to be constantly flowing through the Earth will scatter off a free electron in the superconductor. In a superconductor, the free electrons are bound into Cooper pairs with a binding energy of a little less than 1 meV. If a dark matter particle has enough energy to pull an electron above the material's band gap, it will break the Cooper pair. In this way, the superconductor absorbs the energy of the incoming dark matter particle.
Then a second device (a calorimeter) measures the heat energy deposited in the absorber, providing direct evidence of the dark matter particle.

The physicists predict that reasonable improvements in current detector technology could make this concept feasible in the near future. One of the biggest challenges (as in all dark matter detectors) will be to reduce the noise from non-dark-matter sources, such as thermal and environmental noise. If the superconductor detector can be built, it would provide the most sensitive test of dark matter to date and give scientists a better chance of finding out what the majority of matter in the universe is made of. [17]

Bright sparks shed new light on the dark matter riddle

The origin of matter in the universe has puzzled physicists for generations. Today, we know that matter only accounts for 5% of our universe; another 25% is constituted of dark matter. And the remaining 70% is made up of dark energy. Dark matter itself represents an unsolved riddle.

Physicists believe that such dark matter is composed of (as yet undefined) elementary particles that stick together thanks to gravitational force. In a study recently published in EPJ C, scientists from the CRESST-II research project use the so-called phonon-light technique to detect dark matter.

They are the first to use a detection probe that operates with such a low trigger threshold, which yields suitable sensitivity levels to uncover the as-yet elusive particles responsible for dark matter.

Until quite recently, the so-called WIMP - Weakly Interacting Massive Particle - was the preferred candidate for a new elementary particle to explain dark matter. However, the asymmetric dark matter particle models have attracted more and more interest in the past few years.

The experimental detection is no different from the scattering of two billiard balls, as the particle scatters on an atomic nucleus. The detection method is based on the fact that the scattering would heat up a calcium tungstate (CaWO4) crystal.

The challenge: the lighter the dark matter particle is, the smaller the energy deposited in the crystal is. Currently, no other direct dark matter search method has a threshold for nuclear recoils as low as 0.3 kiloelectronVolt (keV).

As such, the CRESST-II team are the first to ever probe dark matter particle masses at such low mass scale (below one GeV/c^2-as far as 0.5GeV/c^2).

The next-generation CRESST-III detector is currently being upgraded and promises to reach thresholds of 100 electronVolts (eV), following successful tests of prototypes.

Results on light dark matter particles with a low-threshold CRESST-II detector.
http://dx.doi.org/10.1140/epjc/s10052-016-3877-3

[16]

Quantum dots used to convert infrared light to visible light

One way to make a solar cell more efficient would be to increase the amount of light energy that is able to be captured and converted by it to electrical energy, and one of the ways to make that happen would be to find a way to capture and use photons that are below their normal bandgap. To accomplish that goal the team at MIT sought to upconvert photons in infrared light to visible light.

Their approach was to use two films placed on top of a clear plate of glass. The film layer on the bottom was made using a type of quantum dot—an inorganic semiconductor lead sulphid which had been coated with a single layer of fatty acids to make the surface passive. The top film layer was crystalline and made of rubrene, an organic molecule.

In the two film approach, the top film absorbs infrared light, and the energy from it is then transferred to the bottom film. That energy, which exists in the form of excitons is then diffused as it passes through the rubrene—a process called triplet–triplet annihilation. They tested the films by shining an infrared laser at the finished product and found it glowed with visible light—it works, the team notes, because the collision of two low-energy excitons create high-energy excitons, i.e. singlets, which can emit visible light. The team reports that the films are quite efficient at converting the infrared light to visible light.

Besides the possible use in solar cells the films might also be used in cameras, allowing, for example, a visual representation of what is going on in the fog covering a roadway, or in creating better night-vision goggles. The team has plans to improve their film approach, hopefully optimizing it to make it more efficient and perhaps allowing for converting longer infrared wavelengths. [15]

Pacific Storm Julio Unleashes Powerful 'Dark Lightning' Flash

NASA's Fermi Gamma-ray Space Telescope is designed to detect the brightest explosions in the universe — gamma-rays emitted from sources like supermassive black holes or stars that go supernova. But gamma-rays, which are invisible to the naked eye and last only a few thousandths of a second, can also come from sources on Earth.

TGFs rank among the highest-energy forms of light that naturally occur on Earth, and they can be produced by the powerful electric fields in thunderstorms, which is why they are sometimes called "dark lightning." According to the space agency, there are an estimated 1,100 TGFs every day. Previous research using Fermi data has even shown these bursts can fling antimatter into space.

Scientists have only recently been able to link the phenomenon of dark lightning with specific storms. Fermi, which launched in June 2008, can see TGFs that occur within about 500 miles (800 kilometers) of the telescope, which was not precise enough to determine the exact source of a superquick flash of energy.

But in 2012, scientists showed that big bursts of radio emissions — initially thought to be signals from actual lightning — occur almost simultaneously with TGFs.

Now that the two phenomena are associated, researchers can pinpoint the source of gamma-ray flashes with much greater precision, according to NASA.

The World Wide Lightning Location Network, based in Seattle, spotted a lightning-like radio burst near Fermi just 1.89 milliseconds after the TGF was detected.

NASA scientists think the two signals must be related.

Julio has strengthened into a Category 3 hurricane as it nears Hawaii. As of 5 a.m. EDT (0900 GMT) today (Aug. 8), the storm was 970 miles (1,560 km) east of Hilo, a city on the Big Island, with wind speeds of up to 120 mph (193 km/h), according to the National Weather Service. Julio is following Hurricane Iselle, which, last night (Aug. 7), became the first hurricane to make landfall on Hawaii in 22 years, though it has since been downgraded to a tropical storm. [14]

Researchers may have uncovered a way to observe dark matter thanks to a discovery involving X-ray emissions.

Anyone with a passing knowledge of space and astronomy has heard of dark matter, a material believed to account for most of the known universe. We say "believed" because technically it hasn't been observed; the only reason we know it exists is because of gravitational effects on nearby objects, but otherwise it's completely invisible to light. But a major discovery this week suggests that invisibility doesn't extend to X-Ray emissions, which scientists may finally have used to detect dark matter in the universe.

It all happened when astronomers were reviewing data collected by the European Space Agency's XMM-Newton spacecraft and noticed a spike in X-Ray emissions. The anomaly came from two celestial objects - the Andromeda galaxy and Perseus galaxy cluster specifically - but didn't correspond to any known particle or atom. What the researchers did notice, however, was that it lined up perfectly with the theoretical behaviors of dark matter, allowing us to finally "see" it for the first time.

"With the goal of verifying our findings," said Alexey Boyarsky of Switzerland's École Polytechnique Fédérale de Lausanne, "we then looked at data from our own galaxy, the Milky Way, and made the same observations."

If the EPFL's findings hold up, this has huge implications for future astronomy research. Our current picture of space accounts for dark matter tangentially since we can't actually see it. But Boyarksy thinks it might be possible to develop technology to observe it directly, which could vastly change our perceptions of outer space.

"Confirmation of this discovery may lead to construction of new telescopes specially designed for studying the signals from dark matter particles," Boyarsky explain. "We will know where to look in order to trace dark structures in space and will be able to reconstruct how the universe has formed."

That also sounds handy if we ever get warp technology off the ground and need to chart a path around dark matter, but I'm probably getting ahead of myself on that score. [13]

New revelations on dark matter and relic neutrinos

The Planck collaboration, which notably includes the CNRS, CEA, CNES and several French universities, has disclosed, at a conference in Ferrara, Italy, the results of four years of observations from the ESA's Planck satellite. The satellite aims to study relic radiation (the most ancient light in the Universe). This light has been measured precisely across the entire sky for the first time, in both intensity and polarization, thereby producing the oldest image of the Universe. This primordial light lets us "see" some of the most elusive particles in the Universe: dark matter and relic neutrinos.

Between 2009 and 2013, the Planck satellite observed relic radiation, sometimes called cosmic microwave background (CMB) radiation. Today, with a full analysis of the data, the quality of the map is now such that the imprints left by dark matter and relic neutrinos are clearly visible.

Already in 2013, the map for variations in light intensity was released, showing where matter was in the sky 380,000 years after the Big Bang. Thanks to the measurement of the polarization of this light (in four of seven frequencies, for the moment), Planck can now see how this material used to move. Our vision of the primordial Universe has thus become dynamic. This new dimension, and the quality of the data, allows us to test numerous aspects of the standard model of cosmology. In particular, they illuminate the most elusive of particles: dark matter and neutrinos.

New constraints on dark matter

The Planck collaboration results now make it possible to rule out an entire class of models of dark matter, in which dark matter-antimatter annihilation is important. Annihilation is the process whereby a particle and its antiparticle jointly disappear, followed by a release in energy.

The basic existence of dark matter is becoming firmly established, but the nature of dark matter particles remains unknown. There are numerous hypotheses concerning the physical nature of this matter, and one of today's goals is to whittle down the possibilities, for instance by searching for the effects of this mysterious matter on ordinary matter and light. Observations made by Planck show that it is not necessary to appeal to the existence of strong dark matter-antimatter annihilation to explain the dynamics of the early universe. Such events would have produced enough energy to exert an influence on the evolution of the light-matter fluid in the early universe, especially around the time relic radiation was emitted. However, the most recent observations show no hints that this actually took place.

These new results are even more interesting when compared with measurements made by other instruments. The satellites Fermi and Pamela, as well as the AMS-02 experiment aboard the International Space Station, have all observed an excess of cosmic rays, which might be interpreted as a consequence of dark matter annihilation. Given the Planck observations, however, an alternative explanation for these AMS-02 or Fermi measurements—such as radiation from undetected pulsars—has to be considered, if one is to make the reasonable hypothesis that the properties of dark matter particles are stable over time.

Additionally, the Planck collaboration has confirmed that dark matter comprises a bit more than 26% of the Universe today (figure deriving from its 2013 analysis), and has made more accurate maps of the density of matter a few billion years after the Big Bang, thanks to measurements of temperature and B-mode polarization.

Neutrinos from the earliest instants detected

The new results from the Planck collaboration also inform us about another type of very elusive particle, the neutrino. These "ghost" particles, abundantly produced in our Sun for example, can pass through our planet with almost no interaction, which makes them very difficult to detect. It is therefore not realistic to directly detect the first neutrinos, which were created within the first second after the Big Bang, and which have very little energy. However, for the first time, Planck has unambiguously detected the effect these relic neutrinos have on relic radiation maps.

The relic neutrinos detected by Planck were released about one second after the Big Bang, when the Universe was still opaque to light but already transparent to these particles, which can freely escape from environments that are opaque to photons, such as the Sun's core. 380,000 years later, when relic radiation was released, it bore the imprint of neutrinos because photons had gravitational interaction with these particles. Observing the oldest photons thus made it possible to confirm the properties of neutrinos.

Planck observations are consistent with the standard model of particle physics. They essentially exclude the existence of a fourth species of neutrinos, previously considered a possibility based on the final data from the WMAP satellite, the US predecessor of Planck. Finally, Planck makes it possible to set an upper limit to the sum of the mass of neutrinos, currently established at 0.23 eV (electron-volt).

The full data set for the mission, along with associated articles that will be submitted to the journal Astronomy & Astrophysics (A&A), will be available December 22 on the ESA web site. [12]

The Big Bang

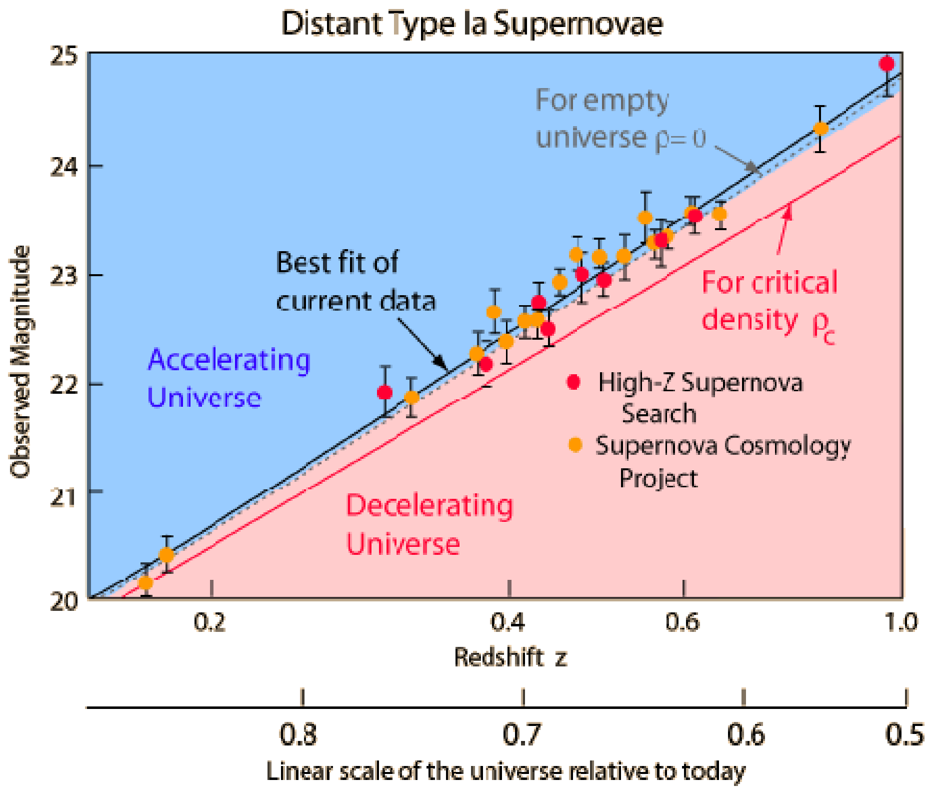
The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting

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.

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

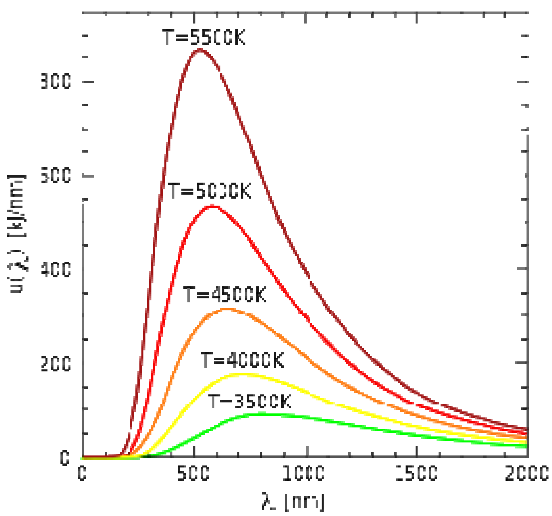
Dark matter is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant 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.

The Weak Interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry.

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

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

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

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

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

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

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

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

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

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.

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

The Sterile Neutrino

By definition the sterile neutrino does not participate in the electromagnetic and weak interactions, only the gravitational force gives its mass. There should be one strange neutrino that changes the diffraction patterns of the electromagnetic oscillations leaving the low frequencies side of the Planck Distribution Law with non-compensated high frequency side. Since the neutrino oscillation and the general weak interaction this sterile neutrino can be oscillate to another measurable neutrino.

The change of the temperature at the Big Bang was the main source for this asymmetry and the creation of the dark matter by the Baryogenesis.[10] Later on also the weak interaction can change the rate of the dark matter, but less influencing it, see the temperature changes of the dark side in the Planck Distribution Law.

The Weak Interaction basically an electric dipole change and transferring the electric charge from one side of the diffraction pattern to the other side. If there is no other side (dark matter), the neutrino oscillation helps to change the frequency of the electromagnetic oscillations, causing real diffraction patterns and leaving the non – compensated side of the Planck Distribution curve for the invisible 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]

Conclusions

If the EPFL's findings hold up, this has huge implications for future astronomy research. Our current picture of space accounts for dark matter tangentially since we can't actually see it. But Boyarksy thinks it might be possible to develop technology to observe it directly, which could vastly change our perceptions of outer space. [13]
Between 2009 and 2013, the Planck satellite observed relic radiation, sometimes called cosmic microwave background (CMB) radiation. Today, with a full analysis of the data, the quality of the map is now such that the imprints left by dark matter and relic neutrinos are clearly visible. [12]
The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.
The 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] The sterile neutrino [11] disappears in the neutrino oscillation.

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