Dark Matter Quantum Technology

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Author: George Rajna

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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Fermilab scientists to look for dark matter using quantum technology

Fermilab scientists are harnessing quantum technology in the search for dark matter.

For decades, physicists have been searching for the elusive stuff, which doesn't emit light but appears to make up the vast majority of matter in the universe. Several theoretical particles have been proposed as dark matter candidates, including weakly interacting massive particles (WIMPs) and axions.

Fermilab's Aaron Chou is leading a multi-institutional consortium consortium to apply the techniques of quantum metrology to the problem of detecting axion dark matter. The project, which brings together scientists at Fermilab, the National Institute of Standards and Technology, the University of Chicago, University of Colorado and Yale University, was recently awarded $2.1 million over two years through the Department of Energy's Quantum Information Science-Enabled Discovery (QuantISED) program, which seeks to advance science through quantum-based technologies.

If the scientists succeed, the discovery could solve several cosmological mysteries at once.

"It'd be the first time that anybody had found any direct evidence of the existence of dark matter," said Fermilab's Daniel Bowring, whose work on this effort is supported by a DOE Office of Science Early Career Research Award. "Right now, we're inferring the existence of dark matter from the behavior of astrophysical bodies. There's very good evidence for the existence of dark matter based on those observations, but nobody's found a particle yet."

The axion search

Finding an axion would also resolve a discrepancy in particle physics called the strong CP problem. Particles and antiparticles are "symmetrical" to one another: They exhibit mirror-image behavior in terms of electrical charge and other properties.

The strong force – one of the four fundamental forces of nature – obeys CP symmetry. But there's no reason, at least in the Standard Model of physics, why it should. The axion was first proposed to explain why it does.

Finding an axion is a delicate endeavor, even compared to other searches for dark matter. An axion's mass is vanishingly low—somewhere between a millionth and a thousandth of an electronvolt. By comparison, the mass of a WIMP is expected to be between a trillion and quadrillion times more massive—in the range of a billion electronvolts—which means they're heavy enough that they could occasionally produce a signal by bumping into the nuclei of other atoms. To look for WIMPs, scientists fill detectors with liquid xenon (for example, in the LUX-ZEPLIN dark matter experiment at Sanford Underground Research Facility in South Dakota) or germanium crystals (in the SuperCDMS Soudan experiment in Minnesota) and look for indications of such a collision.

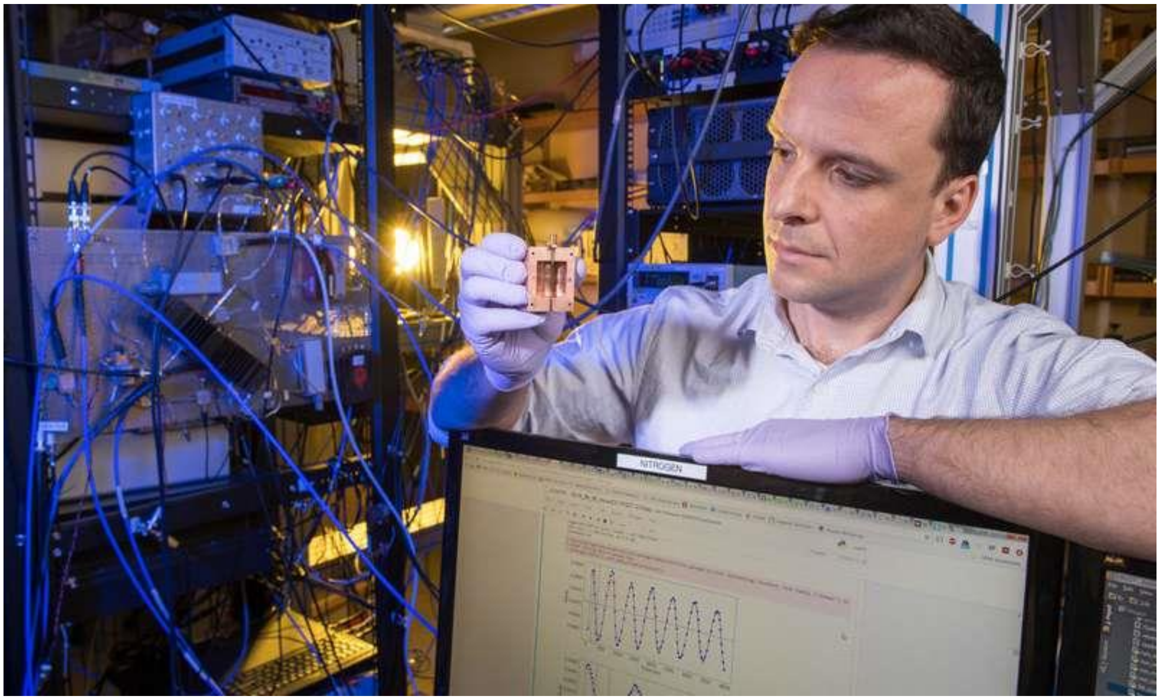
"You can't do that with axions because they're so light," Bowring said. "So the way that we look for axions is fundamentally different from the way we look for more massive particles."

When an axion encounters a strong magnetic field, it should—at least in theory—produce a single microwave-frequency photon, a particle of light. By detecting that photon, scientists should be able to confirm the existence of axions. The Axion Dark Matter eXperiment (ADMX) at the University of Washington and the HAYSTAC experiment at Yale are attempting to do just that.

Those experiments use a strong superconducting magnet to convert axions into photons in a microwave cavity. The cavity can be tuned to different resonant frequencies to boost the interaction between the photon field and the axions. A microwave receiver then detects the signal of photons resulting from the interaction. The signal is fed through an amplifier, and scientists look for that amplified signal.

"But there is a fundamental quantum limit to how good an amplifier can be," Bowring said.

Photons are ubiquitous, which introduces a high degree of noise that must be filtered from the signal detected in the microwave cavity. And at higher resonant frequencies, the signal-to-noise ratio gets progressively worse.



Daniel Bowring holds up a component for detecting dark matter particles called axions. Credit: Reidar Hahn

Both Bowring and Chou are exploring how to use technology developed for quantum computing and information processing to get around this problem. Instead of amplifying the signal and sorting it from the noise, they aim to develop new kinds of axion detectors that will count photons very precisely—with qubits.

The qubit advantage

In a quantum computer, information is stored in qubits, or quantum bits. A qubit can be constructed from a single subatomic particle, like an electron or a photon, or from engineered metamaterials such as superconducting artificial atoms. The computer's design takes advantage of the particles' two-state quantum systems, such as an electron's spin (up or down) or a photon's polarization (vertical or horizontal). And unlike classical computer bits, which have one of only two states (one or zero), qubits can also exist in a quantum superposition, a kind of addition of the particle's two quantum states. This feature has myriad potential applications in quantum computing that physicists are just starting to explore.

In the search for axions, Bowring and Chou are using qubits. For a traditional antenna-based detector to notice a photon produced by an axion, it must absorb the photon, destroying it in the process. A qubit, on the other hand, can interact with the photon many times without annihilating it. Because of this, the qubit-based detector will give the scientists a much higher chance of spotting dark matter.

"The reason we want to use quantum technology is that the quantum computing community has already had to develop these devices that can manipulate a single microwave photon," Chou said. "We're kind of doing the same thing, except a single photon of information that's stored inside this container is not something that somebody put in there as part of the computation. It's something that the dark matter put in there."

Light reflection

Using a qubit to detect an axion-produced photon brings its own set of challenges to the project. In many quantum computers, qubits are stored in cavities made of superconducting materials. The superconductor has highly reflective walls that effectively trap a photon long enough to perform computations with it. But you can't use a superconductor around high-powered magnets like the ones used in Bowring and Chou's experiments.

"The superconductor is just ruined by magnets," Chou said. Currently, they're using copper as an ersatz reflector.

"But the problem is, at these frequencies the copper will store a single photon for only 10,000 bounces instead of, say, a billion bounces off the mirrors," he said. "So we don't get to keep these photons around for quite as long before they get absorbed."

And that means that they don't stick around long enough to be picked up as a signal. So the researchers are developing another, better photon container.

"We're trying to make a cavity out of very low-loss crystals," Chou said.

Think of a windowpane. As light hits it, some photons will bounce off it, and others will pass through. Place another piece of glass behind the first. Some of the photons that passed through the first will bounce off the second, and others will pass through both pieces of glass. Add a third layer of glass, and a fourth, and so on.

"Even though each individual layer is not that reflective by itself, the sum of the reflections from all the layers gives you a pretty good reflection in the end," Chou said. "We want to make a material that traps light for a long time."

Bowring sees the use of quantum computing technology in the search for dark matter as an opportunity to reach across the boundaries that often keep different disciplines apart.

"You might ask why Fermilab would want to get involved in quantum technology if it's a particle physics laboratory," he said. "The answer is, at least in part, that quantum technology lets us do particle physics better. It makes sense to lower those barriers." [19]

Gravitational wave detectors to search for dark matter

Gravitational wave detectors might be able to detect much more than gravitational waves. According to a new study, they could also potentially detect dark matter, if dark matter is composed of a particular kind of particle called a "dark photon." In the future, LIGO (Laser Interferometer Gravitational Wave Observatory) scientists plan to implement a search for dark photons, which will include certain previously unexplored regions of the dark photon parameter space.

A team of physicists, Aaron Pierce, Keith Riles, and Yue Zhao from the University of Michigan, have reported their proposal for using gravitational wave detectors to search for dark matter in a recent paper published in *Physical Review Letters*.

"This proposal nicely bridges the newly born field of gravitational wave astronomy with that of particle physics," Zhao told *Phys.org*. "Without any modifications, a gravitational wave detector can be used as a very sensitive direct dark matter detector, with the potential for a five-sigma discovery of dark matter."

As the physicists explain in their paper, if dark photons have a very light mass, then they can be considered to behave like an oscillating background field, with the oscillation frequency determined by their mass. Gravitational wave detectors could potentially detect these oscillations because the oscillations may affect test objects placed in the gravitational wave detectors. For example, if two test objects located at different positions in the detector experience different displacements, this difference may be due to the relative phase of the dark photonfield's oscillations at these different positions.

The physicists expect that both present Earth-based gravitational wave detectors such as LIGO, as well as future space-based gravitational wave detectors such as LISA (Laser Interferometer Space Antenna), will have the ability to search for dark photon dark matter. Using more than one detector would allow for cross-checking and better sensitivity.

In the future, the scientists plan to work on further developing the new dark matter search method and determining exactly what kind of signal a gravitational wave detector would receive if a dark photon were nearby.

"We plan to push this work well beyond a theoretical proposal," Zhao said. "First, we plan to carry out the data analysis using a simplified signal model and a straightforward search algorithm. Then we will gradually refine our search method and include a detailed simulation of the signal and detector response." [18]

Gravitational wave detectors could shed light on dark matter

A global team of scientists, including two University of Mississippi physicists, has found that the same instruments used in the historic discovery of gravitational waves caused by colliding black holes could help unlock the secrets of dark matter, a mysterious and as-yet-unobserved component of the universe.

The research findings by Emanuele Berti, UM associate professor of physics and astronomy, Shrobana Ghosh, a graduate student, and their colleagues appears in the September issue of Physical Review Letters, one of the most prestigious peer-reviewed academic journals in the field. "Stochastic and resolvable gravitational waves from ultralight bosons" is co-authored by fellow scientists Richard Brito, Enrico Barausse, Vitor Cardoso, Irina Dvorkin, Antoine Klein and Paolo Pani.

The nature of dark matter remains unknown, but scientists estimate that it is five times as abundant as ordinary matter throughout the universe.

"The nature of dark matter is one the greatest mysteries in physics," Berti said. "It is remarkable that we can now do particle physics – investigate the "very small" – by looking at gravitational-wave emission from black holes, the largest and simplest objects in the universe."

PRL is one of several publications produced by the American Physical Society and American Institute of Physics. It contains papers considered to represent significant advances in research, and therefore, published quickly in short, letter format for a broad audience of physicists.

This paper details calculations by the scientists, who work in Germany, France, Italy, Portugal and the U.S., show that gravitational-wave interferometers can be used to indirectly detect the presence of dark matter.

A companion paper by the team, "Gravitational wave searches for ultralight bosons with LIGO and LISA," also has been accepted and will appear in Physical Review D.

Calculations show that certain types of dark matter could form giant clouds around astrophysical black holes. If ultralight scalar particles exist in nature, fast-spinning black holes would trigger the growth of such scalar "condensates" at the expense of their rotational energy, producing a cloud that rotates around the black hole, now more slowly-spinning, and emits gravitational waves, pretty much like a giant lighthouse in the sky.

"One possibility is that dark matter consists of scalar fields similar to the Higgs boson, but much lighter than neutrinos," Pani said. "This type of dark matter is hard to study in particle accelerators, such as the Large Hadron Collider at CERN, but it may be accessible to gravitational-wave detectors."

The team led by Brito studied gravitational waves emitted by the "black hole plus cloud" system. Depending on the mass of the hypothetical particles, the signal is strong enough to be detected by the Laser Interferometer Gravitational-wave Observatory, with instruments in Louisiana and Washington, and its European counterpart Virgo, as well as by the future space mission Laser Interferometer Space Antenna.

"Surprisingly, gravitational waves from sources that are too weak to be individually detectable can produce a strong stochastic background," Brito said. "This work suggests that a careful analysis of the background in LIGO data may rule out – or detect – ultralight dark matter by gravitational-wave interferometers.

"This is a new, exciting frontier in astroparticle physics that could shed light on our understanding of the microscopic universe."

LIGO has been offline for a few months for upgrades. The team plans to announce new, exciting results from its second observing run soon.

"Our work shows that careful analysis of stochastic gravitational waves in the data they have already taken may be used to place interesting constraints on the nature of dark matter," Berti said.

This innovative work "confirms the high quality of the work in astroparticle physics and gravitationalwave astronomy done by members of the gravitational physics group at UM, widely recognized as one of the leaders in the field," said Luca Bombelli, chair and professor of physics and astronomy at Ole Miss. [17]

Synopsis: Dark Photon Conjecture Fizzles

The lack of so-called “dark photons” in electron-positron collision data rules out scenarios in which these hypothetical particles explain the muon’s magnetic moment.

Dark photons sound like objects confused about their purpose, but in reality they are part of a comprehensive theory of dark matter. Researchers imagine that dark photons have photon-like interactions with other dark matter particles. And these hypothetical particles have recently gained interest because they might explain why the observed value of the muon’s anomalous magnetic moment disagrees slightly with predictions. However, this muon connection now appears to have been ruled out by the BaBar Collaboration at the SLAC National Accelerator Laboratory in California. The researchers found no signal of dark photons in their electron-positron collision data.

Like the normal photon, the dark photon would carry an electromagnetic-like force between dark matter particles. It could also potentially have a weak coupling to normal matter, implying that dark photons could be produced in high-energy collisions. Previous searches have failed to find a signature, but they have generally assumed that dark photons decay into electrons or some other type of visible particle.

For their new search, the BaBar Collaboration considered a scenario in which a dark photon is created with a normal photon in an electron-positron collision and then decays into invisible particles, such as other dark matter particles. In this case, only one particle—the normal photon—would be detected, and it would carry less than the full energy from the collision. Such missingenergy events can occur in other ways, so the team looked for a “bump” or increase in events at a specific energy that would correspond to the mass of the dark photon. They found no such bump up to masses of 8 GeV. The null result conflicts with models in which a dark photon contribution brings the predicted muon magnetic moment in line with observations. [16]

Exchanges of identity in deep space

By reproducing the complexity of the cosmos through unprecedented simulations, a new study highlights the importance of the possible behaviour of very high-energy photons. In their journey through intergalactic magnetic fields, such photons could be transformed into axions and thus avoid being absorbed.

Like in a nail-biting thriller full of escapes and subterfuge, photons from far-off light sources such as blazars could experience a continuous exchange of identity in their journey through the universe. This would allow these very tiny particles to escape an enemy which, if encountered, would annihilate them. Normally, very high-energy photons (gamma rays) should "collide" with the background light emitted by galaxies and transform into pairs of matter and antimatter particles, as envisaged by the Theory of Relativity. For this reason, the sources of very high-energy gamma rays should appear significantly less bright than what is observed in many cases.

A possible explanation for this surprising anomaly is that light photons are transformed into hypothetical weakly interacting particles, "axions," which, in turn, would change into photons, all due to the interaction with magnetic fields. A part of the photons would escape interaction with the intergalactic background light that would make them disappear. The importance of this process is emphasised by a study published in Physical Review Letters, which recreated an extremely refined model of the cosmic web, a network of filaments composed of gas and dark matter present throughout the universe, and of its magnetic fields. These effects are now awaiting comparison with those obtained experimentally through Cherenkov Telescope Array new generation telescopes.

Through complex and unprecedented computer simulations made at the CSCS Supercomputing Centre in Lugano, scholars have reproduced the so-called cosmic web and its associated magnetic fields to investigate the theory that photons from a light source are transformed into axions, hypothetical elementary particles, on interacting with an extragalactic magnetic field. Axions could then be changed back into photons by interacting with other magnetic fields. Researchers Daniele Montanino, Franco Vazza, Alessandro Mirizzi and Matteo Viel write, "Photons from luminous bodies disappear when they encounter extragalactic background light (EBL). But if on their journey they head into these transformations as envisaged by these theories, it would explain why, in addition to giving very important information on processes that occur in the universe, distant celestial bodies are brighter than expected from an observation on Earth. These changes would, in fact, enable a greater number of photons to reach the Earth."

Thanks to the wealth of magnetic fields present in the cosmic web's filaments, which were recreated with the simulations, the conversion phenomenon would seem much more relevant than predicted by previous models: "Our simulations reproduce a very realistic picture of the cosmos' structure. From what we have observed, the distribution of the cosmic web envisaged by us would markedly increase the probability of these transformations." The next step in the research is to compare simulation results with the experimental data obtained through the use of the Cherenkov Telescope Array Observatories detectors, the new-generation astronomical observatories, one of which is positioned in the Canary Islands and the other in Chile. They will study the universe through very high-energy gamma rays. [15]

Astronomers may have detected the first direct evidence of dark matter

Scientists have detected a mysterious X-ray signal that could be caused by dark matter streaming out of our Sun’s core.

Now scientists at the University of Leicester have identified a signal on the X-ray spectrum which appears to be a signature of ‘axions’ - a hypothetical dark matter particle that’s never been detected before.

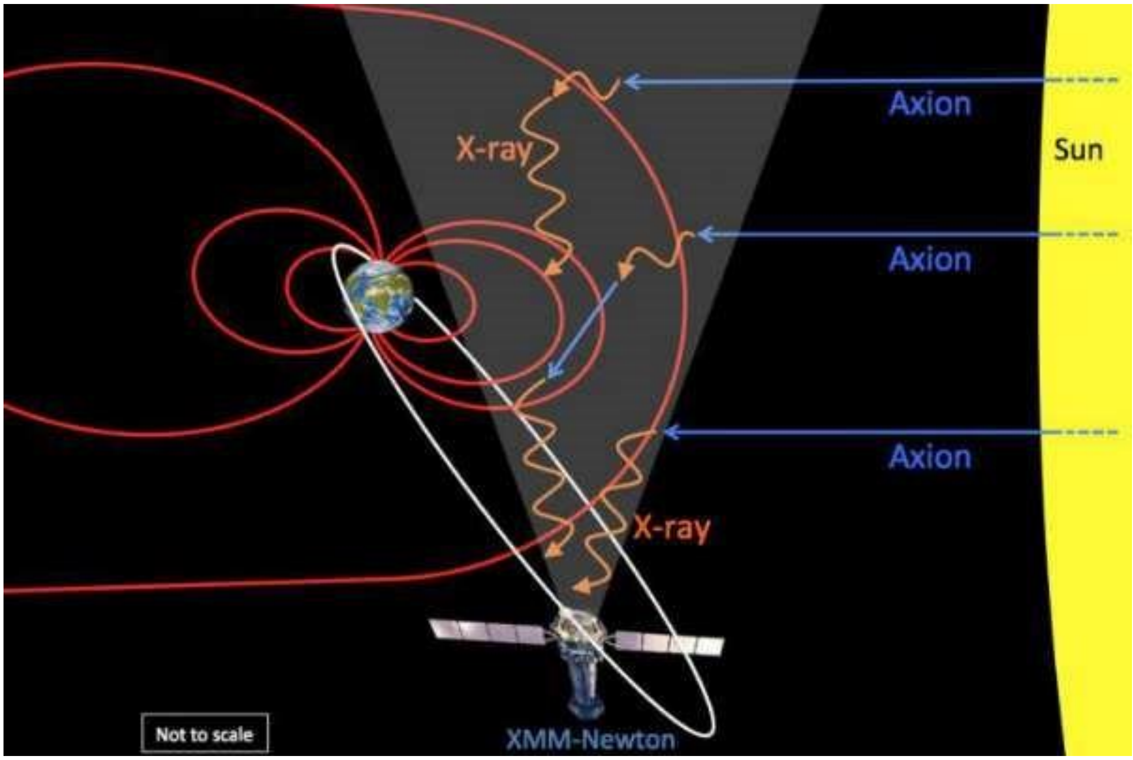
While we can't get too excited just yet - it will take years to confirm whether this signal really is dark matter - the discovery would completely change our understanding of how the Universe works. After all, dark matter is the force that holds our galaxies together, so learning more about it is pretty important.

The researchers first detected the signal while searching through 15 years of measurements taking by the European Space Agency’s orbiting XMM-Newton space observatory.

Unexpectedly, they noticed that the intensity of X-rays recorded by the spacecraft rose by about 10% whenever XMM-Newton was at the boundary of Earth's magnetic field facing the Sun - even once they removed all the bright X-ray sources from the sky. Usually, that X-ray background is stable. "The X-ray background - the sky, after the bright X-ray sources are removed - appears to be unchanged whenever you look at it," said Andy Read, from the University of Leicester, one of the lead authors on the paper, in a press release. "However, we have discovered a seasonal signal in this X-ray background, which has no conventional explanation, but is consistent with the discovery of axions."

Researchers predict that axions, if they exist, would be produced invisibly by the Sun, but would convert to X-rays as they hit Earth's magnetic field. This X-ray signal should in theory be strongest when looking through the sunward side of the magnetic field, as this is where the Earth's magnetic field is strongest.

The next step is for the researchers to get a larger dataset from XMM-Newton and confirm the pattern they've seen in X-rays. Once they've done that, they can begin the long process of proving that they have, in fact, detecting dark matter streaming out of our Sun's core.



A sketch (not to scale) shows axions (blue) streaming out of the Sun and then converting into X-rays (orange) in the Earth's magnetic field (red). The X-rays are then detected by the XMM-Newton observatory. [13]

The axion is a hypothetical elementary particle postulated by the Peccei–Quinn theory in 1977 to resolve the strong CP problem in quantum chromodynamics (QCD). If axions exist and have low mass within a specific range, they are of interest as a possible component of cold dark matter. [14]

Hidden photons

Hidden photons are predicted in some extensions of the Standard Model of particle physics, and unlike WIMPs they would interact electromagnetically with normal matter. Hidden photons also have a very small mass, and are expected to oscillate into normal photons in a process similar to neutrino oscillation. Observing such oscillations relies on detectors that are sensitive to extremely small electromagnetic signals, and a number of these extremely difficult experiments have been built or proposed.

A spherical mirror is ideal for detecting such light because the emitted photons would be concentrated at the sphere's centre, whereas any background light bouncing off the mirror would pass through a focus midway between the sphere's surface and centre. A receiver placed at the centre could then pick up the dark-matter-generated photons, if tuned to their frequency – which is related to the mass of the incoming hidden photons – with mirror and receiver shielded as much as possible from stray electromagnetic waves.

Ideal mirror at hand

Fortunately for the team, an ideal mirror is at hand: a 13 m2 aluminium mirror used in tests during the construction of the Pierre Auger Observatory and located at the Karlsruhe Institute of Technology. Döbrich and co-workers have got together with several researchers from Karlsruhe, and the collaboration is now readying the mirror by adjusting the position of each of its 36 segments to minimize the spot size of the focused waves. They are also measuring background radiation within the shielded room that will house the experiment. As for receivers, the most likely initial option is a set of low-noise photomultiplier tubes for measurements of visible light, which corresponds to hidden-photon masses of about 1 eV/C^2. Another obvious choice is a receiver for gigahertz radiation, which corresponds to masses less than 0.001 eV/C^2; however, this latter set-up would require more shielding.

Dark matter composition research - WIMP

The WIMP (Weakly interactive massive particles) form a class of heavy particles, interacting slightly with matter, and constitute excellent candidates with the nonbaryonic dark matter. The neutralino postulated by the supersymetric extensions of the standard model of particle physics. The idea of supersymmetry is to associate each boson to a fermion and vice versa. Each particle is then given a super-partner, having identical properties (mass, load), but with a spin which differes by 1/2. Thus, the number of particles is doubled. For example, the photon is accompanied by a photino, the graviton by a gravitino, the electron of a selectron, etc. Following the impossibility to detect a 511 keV boson (the electron partner), the physicists had to re-examine the idea of an exact symmetry. Symmetry is 'broken' and superpartners have a very important mass. One of these superparticules called LSP (Lightest Supersymmetric Particle) is the lightest of all. In most of the supersymmetric theories (without violation of the R-parity) the LSP is a stable particle because it cannot disintegrate in a lighter element. It is of neutral color and electric charge and is then only sensitive to weak interaction (weak nuclear force). It is then an excellent candidate for the not-baryonic dark matter. [11]

Weakly interacting massive particles

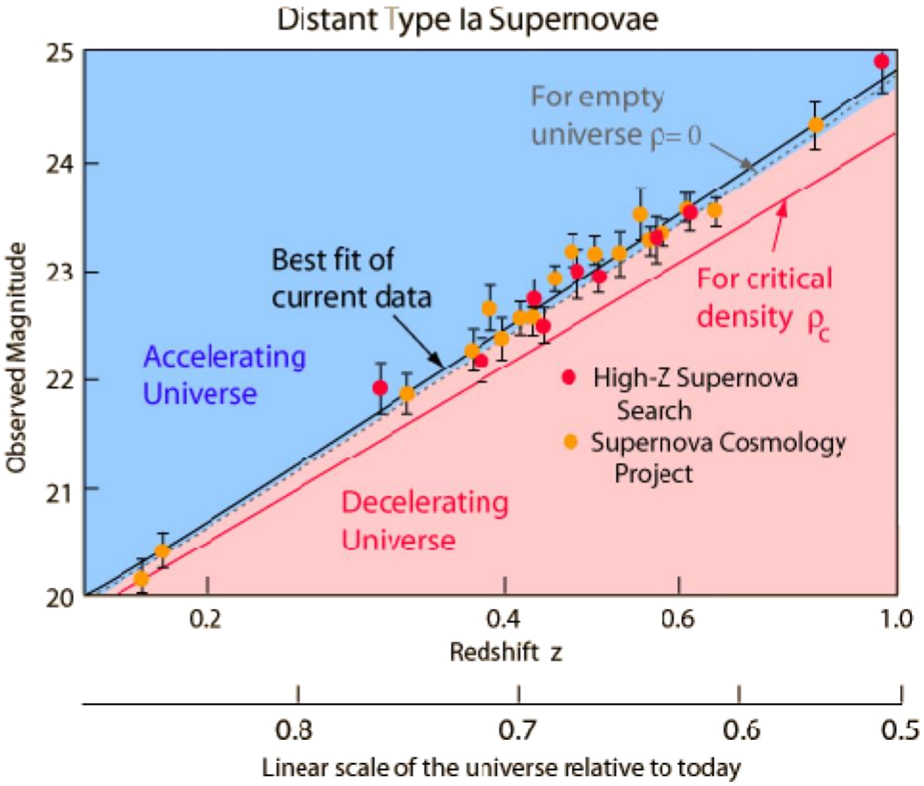
In particle physics and astrophysics, weakly interacting massive particles, or WIMPs, are among the leading hypothetical particle physics candidates for dark matter. The term “WIMP” is given to a dark matter particle that was produced by falling out of thermal equilibrium with the hot dense plasma of the early universe, although it is often used to refer to any dark matter candidate that interacts with standard particles via a force similar in strength to the weak nuclear force. Its name comes from the fact that obtaining the correct abundance of dark matter today via thermal production requires a self-annihilation cross section, which is roughly what is expected for a new particle in the 100 GeV mass range that interacts via the electroweak force. This apparent coincidence is known as the “WIMP miracle”. Because supersymmetric extensions of the standard model of particle physics readily predict a new particle with these properties, a stable supersymmetric partner has long been a prime WIMP candidate. However, recent null results from direct detection experiments including LUX and SuperCDMS, along with the failure to produce evidence of supersymmetry in the Large Hadron Collider (LHC) experiment has cast doubt on the simplest WIMP hypothesis. Experimental efforts to detect WIMPs include the search for products of WIMP annihilation, including gamma

rays, neutrinos and cosmic rays in nearby galaxies and galaxy clusters; direct detection experiments designed to measure the collision of WIMPs with nuclei in the laboratory, as well as attempts to directly produce WIMPs in colliders such as the LHC. [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: $\Lambda = 8\pi\rho_{\text{vac}}$, 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

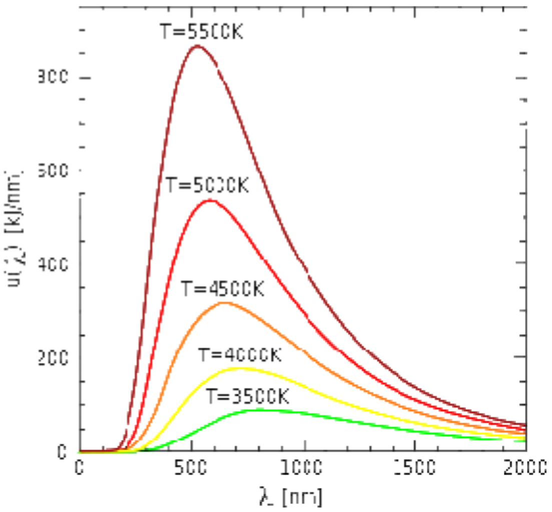
Dark matter is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant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

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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 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

Researchers predict that axions, if they exist, would be produced invisibly by the Sun, but would convert to X-rays as they hit Earth's magnetic field. This X-ray signal should in theory be strongest when looking through the sunward side of the magnetic field, as this is where the Earth's magnetic field is strongest. The high frequency of the X-ray and the uncompensated Planck distribution makes the axion a good candidate to be dark matter.

Hidden photons are predicted in some extensions of the Standard Model of particle physics, and unlike WIMPs they would interact electromagnetically with normal matter.
In particle physics and astrophysics, weakly interacting massive particles, or WIMPs, are among the leading hypothetical particle physics candidates for dark matter.
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]

References

[1] 3 Dimensional String Theory

Author: George Rajna

Publisher: Academia.edu
http://www.academia.edu/3834454/3_Dimensional_String_Theory

[2] Graviton Production By Two Photon and Electron-Photon Processes In Kaluza-Klein Theories With Large Extra Dimensions http://arxiv.org/abs/hep-ph/9909392

[3] Higgs Field and Quantum Gravity

Author: George Rajna

Publisher: Academia.edu
http://www.academia.edu/4158863/Higgs_Field_and_Quantum_Gravity

[4] The Magnetic field of the Electric current

Author: George Rajna

Publisher: Academia.edu
https://www.academia.edu/3833335/The_Magnetic_field_of_the_Electric_current

[5] http://en.wikipedia.org/wiki/Einstein_field_equations

[6] http://en.wikipedia.org/wiki/Dark_matter

[7] http://en.wikipedia.org/wiki/Cosmic_microwave_background

[8] http://en.wikipedia.org/wiki/Thermal_radiation

[9] http://hyperphysics.phy-astr.gsu.edu/hbase/astro/univacc.html

[10] http://en.wikipedia.org/wiki/Weakly_interacting_massive_particles

[11] http://www.darkmatterphysics.com/WIMP.htm

[12] http://physicsworld.com/cws/article/news/2014/oct/13/dark-matter-could-light-up-giantmirror

[13] http://sciencealert.com.au/news/20141810-26360-2.html

[14] http://en.wikipedia.org/wiki/Axion

[15] Exchanges of identity in deep space
https://phys.org/news/2017-09-exchanges-identity-deep-space.html

[16] Synopsis: Dark Photon Conjecture Fizzles
https://physics.aps.org/synopsis-for/10.1103/PhysRevLett.119.131804

[17] Gravitational wave detectors could shed light on dark matter https://phys.org/news/2017-10-gravitational-detectors-dark.html

[18] Gravitational wave detectors to search for dark matter

https://phys.org/news/2018-08-gravitational-detectors-dark.html

[19] Fermilab scientists to look for dark matter using quantum technology

https://phys.org/news/2018-10-fermilab-scientists-dark-quantum-technology.html