Breakthrough in Antimatter Research?

Scientists from the international ALPHA Collaboration just published a paper that has been heralded as a "breakthrough in antimatter research." [12]

Both the planet we live on and the star we orbit are made up of 'normal' matter, and though it features in many science fiction stories, antimatter seems to be incredibly rare in nature. With this new result, we have one of the first hints that we might be able to solve this mystery. [11]

Physicists in the College of Arts and Sciences have made important discoveries regarding Bs meson particles -- something that may explain why the universe contains more matter than antimatter.

Named Ds3(2860), the particle, a new type of meson, was discovered by analyzing data collected with the LHCb detector at CERN's Large Hadron Collider (LHC). The new particle is bound together in a similar way to protons. Due to this similarity, the Warwick researchers argue that scientists will now be able to study the particle to further understand strong interactions.*

Taking into account the Planck Distribution Law of the electromagnetic oscillators, we can explain the electron/proton mass rate and the Weak and Strong Interactions. Lattice QCD gives the same results as the diffraction patterns of the electromagnetic oscillators, explaining the color confinement and the asymptotic freedom of the Strong Interactions.

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Preface

Scientists believe that, 14 billion years ago, energy coalesced to form equal quantities of matter and antimatter. As the universe cooled and expanded, its composition changed. Antimatter all but disappeared after the Big Bang, leaving behind matter to create everything from stars and galaxies to life on Earth.

The discovery of a new particle will "transform our understanding" of the fundamental force of nature that binds the nuclei of atoms, researchers argue. Led by scientists from the University of Warwick, the discovery of the new particle will help provide greater understanding of the strong interaction, the fundamental force of nature found within the protons of an atom's nucleus.

The diffraction patterns of the electromagnetic oscillators give the explanation of the Electroweak and Electro-Strong interactions. [2] Lattice QCD gives the same results as the diffraction patterns which explain the color confinement and the asymptotic freedom.

The hadronization is the diffraction pattern of the baryons giving the jet of the color – neutral particles!

New Study Achieves Breakthrough in Antimatter Research

Scientists from the international ALPHA Collaboration just published a paper that has been heralded as a “breakthrough in antimatter research.”

Published in the journal, Nature, the result of research focus on the properties of antihydrogen.

Through their work, the team has improved our measurements of the charge of this material by a factor of about 20. This allows us to better understand the nature of anitmatter, and the more accurate measurements could ultimately help us answer some of the most fundamental questions plaguing modern physics.

Case in point, one of the most longstanding questions in the study of antimatter (and physics in general) is based on the assumption that the Big Bang created matter and antimatter in equal amounts. If this is indeed the case, and it seems that it is, then why is there currently so much more matter than antimatter in the universe? Where did all the antimatter go?”

UNDERSTANDING CHARGES

According to our understanding of the rules of physics, every particle of matter should have an oppositely charged antiparticle with equal mass. But it seems that the “rules” may be a little bit different than we anticipated.

According to Dr. Andrea Capra, “we take the charge of matter and antimatter for granted, however, you cannot analyze data or make an experiment assuming it’s true.” To that end, if we want to understand what caused the loss of antimatter in our universe, then we need to have a firm understanding of the charge of antimatter.

So, what do the new findings reveal?

They don’t explain why there is so much missing antimatter, but they do help us better understand what didn’t cause the scales to tip in favor of matter.

“That means the electrical charge of antihydrogen – the antimatter analogue of hydrogen – can be ruled out as the answer to the antimatter question,” explains York University Professor Scott Menary, an ALPHA member.

PIECE OF THE PUZZLE

Although we don’t have a final answer, the results do add a piece to the overall puzzle. Moreover, this was just the first experiment that was conducted using the upgraded “ALPHA-2” system, whose largest component (the cooling cryostat) lent itself to the creation of the stable cryogenic environment that allowed for the higher trapping rate of the technology—and this first experiment was remarkably successful, giving us precisely the information that we hoped to gain.

The success of this experiment now prompts the ALPHA Collaboration team to begin working on answer other antimatter questions.

“We will now look at the other pieces of the puzzle, such as the colour of the light emitted by antihydrogen, and test whether hydrogen and antihydrogen emit light in the same way,” says Capra. “We are also working on measuring the gravitational acceleration of antihydrogen and determining whether matter and antimatter have the same gravitational behaviour. The next several years are going to be very exciting."

And hopefully, they will give us ideas regarding the final solution to the missing antimatter. [12]

Left-handed cosmic magnetic field could explain missing antimatter

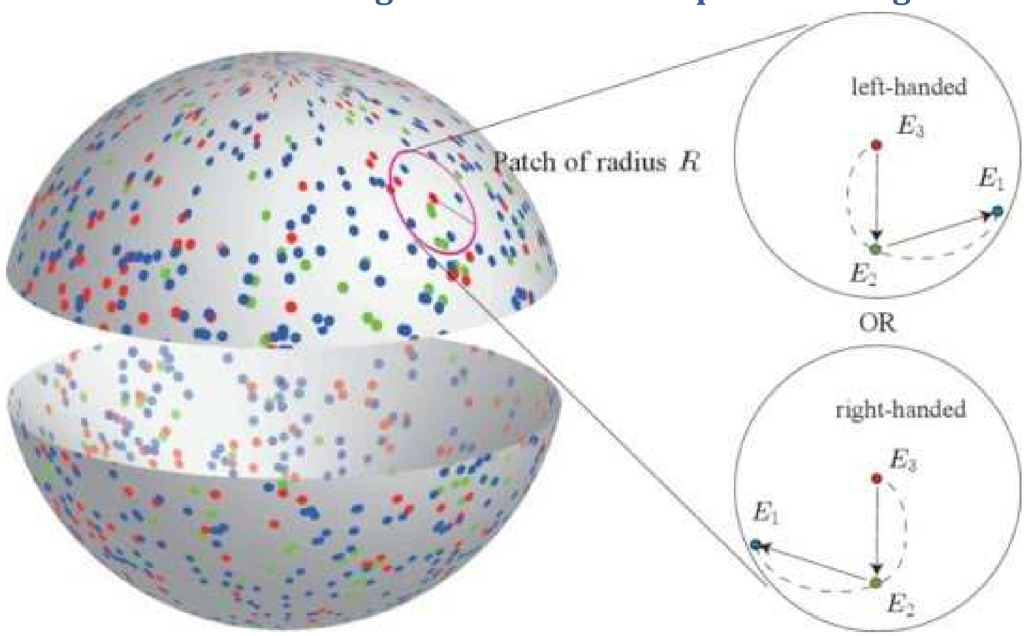

Illustration of the Fermi Gamma ray Space Telescope (FGST) map of the sky with the central band removed to block out gamma rays originating in the Milky Way. Gamma rays of different energies are represented by dots of various colors -- red dots represent arrival locations of very energetic gamma rays, green dots represent lower energy, and blue dots represent lowest energy. The new analysis looks for spiral patterns in the distribution of gamma rays within patches on the sky, with the highest energy gamma ray at the center of the spiral and the lower energy gamma rays further along the spiral. A helical magnetic field in the universe gives an excess of spirals of one handedness - and FGST data shows an excess of left-handed spirals.

The discovery of a 'left-handed' magnetic field that pervades the universe could help explain a long standing mystery -- the absence of cosmic antimatter. A group of scientists, led by Prof Tanmay Vachaspati from Arizona State University in the United States, with collaborators at Washington University and Nagoya University, announce their result in Monthly Notices of the Royal Astronomical Society.

Planets, stars, gas and dust are almost entirely made up of 'normal' matter of the kind we are familiar with on Earth. But theory predicts that there should be a similar amount of antimatter, like normal matter, but with the opposite charge. For example, an antielectron or positron has the same mass as its conventional counterpart, but a positive rather than negative charge.

In 2001 Prof Vachaspati published theoretical models to try to solve this puzzle, which predict that the entire universe is filled with helical (screw-like) magnetic fields. He and his team were inspired to search for evidence of these fields in data from the NASA Fermi Gamma ray Space Telescope (FGST).

FGST, launched in 2008, observes gamma rays (electromagnetic radiation with a shorter wavelength than X-rays) from very distant sources, such as the supermassive black holes found in many large galaxies. The gamma rays are sensitive to effect of the magnetic field they travel through on their long journey to Earth. If the field is helical, it will imprint a spiral pattern on the distribution of gamma rays.

Vachaspati and his team see exactly this effect in the FGST data, allowing them to not only detect the magnetic field but to measure its properties. The data shows not only a helical field, but show that there is an excess of left-handedness -- a fundamental discovery that for the first time suggests the precise mechanism that led to the absence of antimatter.

For example, mechanisms that occur nanoseconds after the Big Bang, when the Higgs field gave masses to all known particles, predict left-handed fields, while mechanisms based on interactions that occur even earlier predict right-handed fields.

Prof Vachaspati commented: "Both the planet we live on and the star we orbit are made up of 'normal' matter, and though it features in many science fiction stories, antimatter seems to be incredibly rare in nature. With this new result, we have one of the first hints that we might be able to solve this mystery." [11]

Physicists closer to understanding balance of matter, antimatter in universe

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The LHCb Collaboration is a multinational experiment that seeks to explore what happened after the Big Bang, causing matter to survive and flourish in the Universe. LHCb is an international experiment, based at CERN, involving more than 800 scientists and engineers from all over the world. At CERN, Stone heads up a team of 15 physicists from Syracuse.

He thinks part of the answer lies in the Bs meson, which contains an antiquark and a strange quark and is bound together by a strong interaction. (A quark is a hard, point-like object found inside a proton and neutron that forms the nucleus of an atom.)

"Many international experiments are interested in the Bs meson because it oscillates between a matter particle and an antimatter particle," says Stone, who heads up Syracuse's High-Energy Physics Group. "Understanding its properties may shed light on charge-parity [CP] violation, which refers to the balance of matter and antimatter in the universe and is one of the biggest challenges of particle physics." [10]

New subatomic particle sheds light on fundamental force of nature

Named Ds3*(2860), the particle, a new type of meson, was discovered by analyzing data collected with the LHCb detector at CERN's Large Hadron Collider (LHC). The new particle is bound together in a similar way to protons. Due to this similarity, the Warwick researchers argue that scientists will now be able to study the particle to further understand strong interactions.

"Calculations of strong interactions are done with a computationally intensive technique called Lattice QCD," says Professor Gershon. "In order to validate these calculations it is essential to be able to compare predictions to experiments. The new particle is ideal for this purpose because it is the first known that both contains a charm quark and has spin 3."

There are six quarks known to physicists; Up, Down, Strange, Charm, Beauty and Top. Protons and neutrons are composed of up and down quarks, but particles produced in accelerators such as the LHC can contain the unstable heavier quarks. In addition, some of these particles have higher spin values than the naturally occurring stable particles.

"Because the Ds3*(2860) particle contains a heavy charm quark it is easier for theorists to calculate its properties. And because it has spin 3, there can be no ambiguity about what the particle is," adds Professor Gershon.

"Therefore it provides a benchmark for future theoretical calculations. Improvements in these calculations will transform our understanding of how nuclei are bound together."

Spin is one of the labels used by physicists to distinguish between particles. It is a concept that arises in quantum mechanics that can be thought of as being similar to angular momentum: in this sense higher spin corresponds to the quarks orbiting each other faster than those with a lower spin.

Warwick Ph.D. student Daniel Craik, who worked on the study, adds "Perhaps the most exciting part of this new result is that it could be the first of many similar discoveries with LHC data. Whether we can use the same technique, as employed with our research into Ds3*(2860), to also improve our understanding of the weak interaction is a key question raised by this discovery. If so, this could help to answer one of the biggest mysteries in physics: why there is more matter than antimatter in the Universe." [9]

Asymmetry in the interference occurrences of oscillators

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

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

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

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

If ϕ is infinitesimal so that $\sin\phi = \phi$, than

(2) $I = n^2 I_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

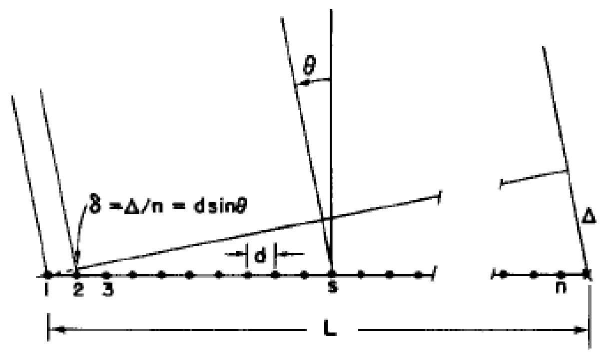


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

Figure 1.) A linear array of n equal oscillators

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

So

(4) $d \sin \theta = m \lambda$

and we get m-order beam if λ less than d. [6]

If d less than λ we get only zero-order one centered at $\theta = 0$. Of course, there is also a beam in the opposite direction. The right chooses of d and λ we can ensure the conservation of charge.

For example

(5) $2(m+1) = n$

Where $2(m+1) = N_p$ number of protons and $n = N_e$ number of electrons.

In this way we can see the H_2 molecules so that 2n electrons of n radiate to 4(m+1) protons, because $d_e > \lambda_e$ for electrons, while the two protons of one H_2 molecule radiate to two electrons of them, because of $d_e < \lambda_e$ for this two protons.

To support this idea we can turn to the Planck distribution law, that is equal with the Bose – Einstein statistics.

Spontaneously broken symmetry in the Planck distribution law

The Planck distribution law is temperature dependent and it should be true locally and globally. I think that Einstein's energy-matter equivalence means some kind of existence of electromagnetic oscillations enabled by the temperature, creating the different matter formulas, atoms molecules, crystals, dark matter and energy.

Max Planck found for the black body radiation

As a function of wavelength (λ), Planck's law is written as:

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

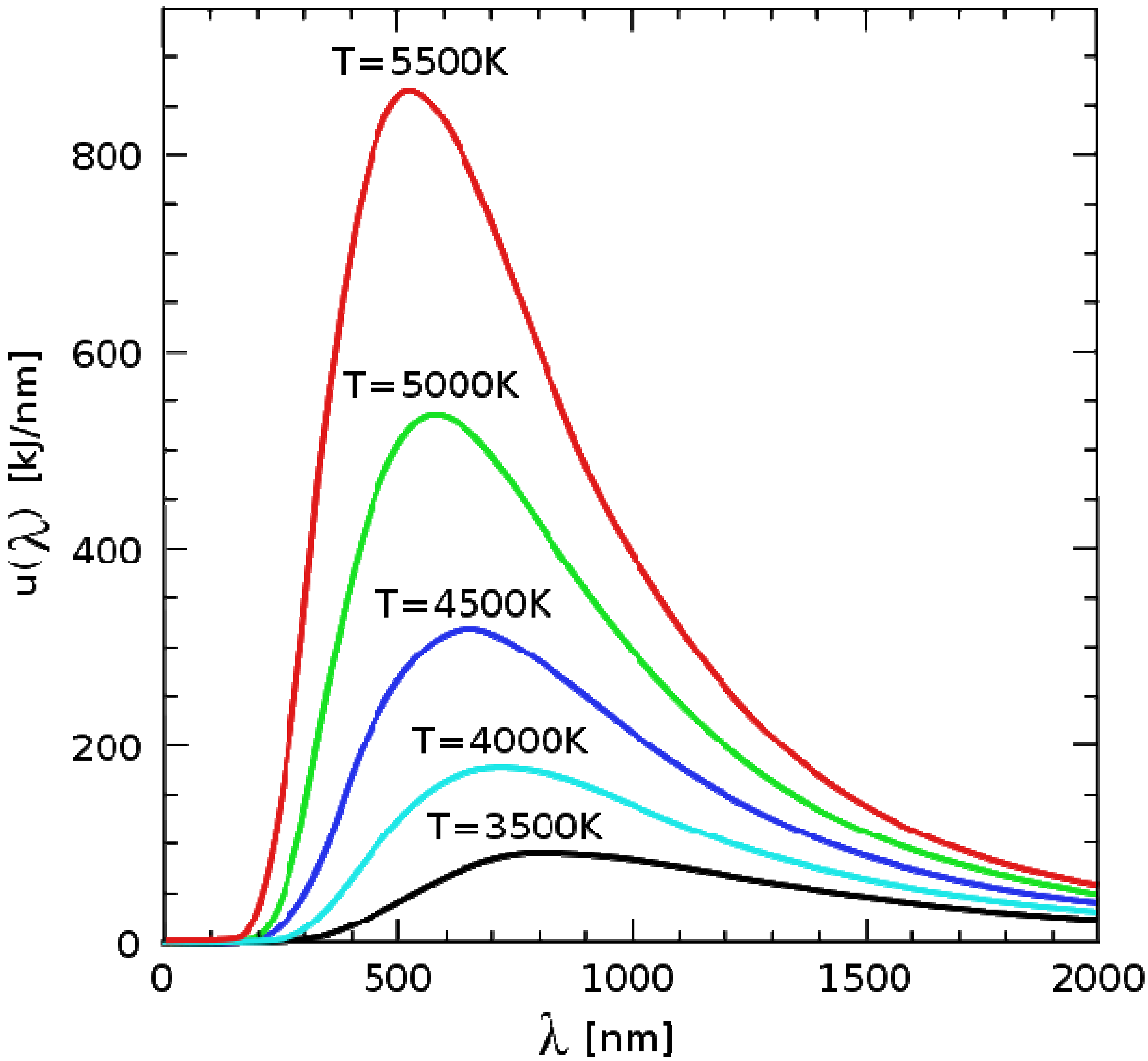


Figure 2. The distribution law for different T temperatures

We see there are two different λ_1 and λ_2 for each T and intensity, so we can find between them a d so that $\lambda_1 < d < \lambda_2$.

We have many possibilities for such asymmetrical reflections, so we have many stable oscillator configurations for any T temperature with equal exchange of intensity by radiation. All of these configurations can exist together. At the λ_{max} is the annihilation point where the configurations are symmetrical. The λ_{max} is changing by the Wien's displacement law in many textbooks.

(7) $$\lambda_{max} = \frac{b}{T}$$

where λ_{max} is the peak wavelength, T is the absolute temperature of the black body, and b is a constant of proportionality called *Wien's displacement constant*, equal to $2.8977685(51)\times10^{-3}$ m·K (2002 CODATA recommended value).

By the changing of T the asymmetrical configurations are changing too.

The structure of the proton

We must move to the higher T temperature if we want look into the nucleus or nucleon arrive to $d<10^{-13}$ cm. [2] If an electron with $\lambda_e < d$ move across the proton then by (5) 2 (m+1) = n with m = 0 we get n = 2 so we need two particles with negative and two particles with positive charges. If the proton can fraction to three parts, two with positive and one with negative charges, then the reflection of oscillators are right. Because this very strange reflection where one part of the proton with the electron together on the same side of the reflection, the all parts of the proton must be quasi lepton so $d > \lambda_q$. One way dividing the proton to three parts is, dividing his oscillation by the three direction of the space. We can order 1/3 e charge to each coordinates and 2/3 e charge to one plane oscillation, because the charge is scalar. In this way the proton has two +2/3 e plane oscillation and one linear oscillation with -1/3 e charge. The colors of quarks are coming from the three directions of coordinates and the proton is colorless. The flavors of quarks are the possible oscillations differently by energy and if they are plane or linear oscillations. We know there is no possible reflecting two oscillations to each other which are completely orthogonal, so the quarks never can be free, however there is asymptotic freedom while their energy are increasing to turn them to orthogonal. If they will be completely orthogonal then they lose this reflection and take new partners from the vacuum. Keeping the symmetry of the vacuum the new oscillations are keeping all the conservation laws, like charge, number of baryons and leptons. The all features of gluons are coming from this model. The mathematics of reflecting oscillators show Fermi statistics.

Important to mention that in the Deuteron there are 3 quarks of +2/3 and -1/3 charge, that is three u and d quarks making the complete symmetry and because this its high stability.

The 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, 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 Strong Interaction - QCD

Confinement and Asymptotic Freedom

For any theory to provide a successful description of strong interactions it should simultaneously exhibit the phenomena of confinement at large distances and asymptotic freedom at short distances. Lattice calculations support the hypothesis that for non-abelian gauge theories the two domains are analytically connected, and confinement and asymptotic freedom coexist.
Similarly, one way to show that QCD is the correct theory of strong interactions is that the coupling extracted at various scales (using experimental data or lattice simulations) is unique in the sense that its variation with scale is given by the renormalization group. The data for αs is reviewed in Section 19. In this section I will discuss what these statements mean and imply. [4]

Lattice QCD

Lattice QCD is a well-established non-perturbative approach to solving the quantum chromodynamics (QCD) theory of quarks and gluons. It is a lattice gauge theory formulated on a grid or lattice of points in space and time. When the size of the lattice is taken infinitely large and its sites infinitesimally close to each other, the continuum QCD is recovered. [6]

Analytic or perturbative solutions in low-energy QCD are hard or impossible due to the highly nonlinear nature of the strong force. This formulation of QCD in discrete rather than continuous space-time naturally introduces a momentum cut-off at the order $1/a$, where a is the lattice spacing, which regularizes the theory. As a result, lattice QCD is mathematically well-defined. Most importantly, lattice QCD provides a framework for investigation of non-perturbative phenomena such as confinement and quark-gluon plasma formation, which are intractable by means of analytic field theories.

In lattice QCD, fields representing quarks are defined at lattice sites (which leads to fermion doubling), while the gluon fields are defined on the links connecting neighboring sites.

QCD

QCD enjoys two peculiar properties:

- **Confinement**, which means that the force between quarks does not diminish as they are separated. Because of this, it would take an infinite amount of energy to separate two quarks; they are forever bound into hadrons such as the proton and the neutron. Although analytically unproven, confinement is widely believed to be true because it explains the consistent failure of free quark searches, and it is easy to demonstrate in lattice QCD.
- **Asymptotic freedom**, which means that in very high-energy reactions, quarks and gluons interact very weakly. This prediction of QCD was first discovered in the early 1970s by David Politzer and by Frank Wilczek and David Gross. For this work they were awarded the 2004 Nobel Prize in Physics.

There is no known phase-transition line separating these two properties; confinement is dominant in low-energy scales but, as energy increases, asymptotic freedom becomes dominant. [5]

Color Confinement

When two quarks become separated, as happens in particle accelerator collisions, at some point it is more energetically favorable for a new quark-antiquark pair to spontaneously appear, than to allow the tube to extend further. As a result of this, when quarks are produced in particle accelerators, instead of seeing the individual quarks in detectors, scientists see "jets" of many color-neutral particles (mesons and baryons), clustered together. This process is called hadronization, fragmentation, or string breaking, and is one of the least understood processes in particle physics. [3]

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]

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. [2]

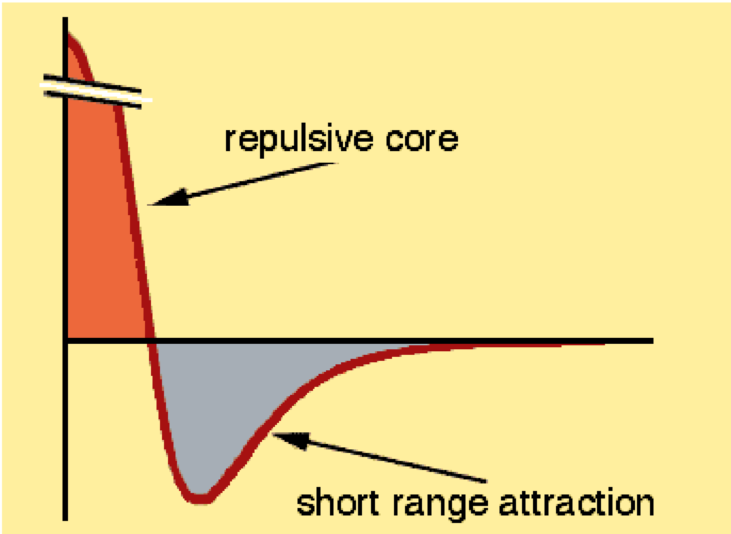
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a 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 potential of the diffraction pattern

The force that holds protons and neutrons together is extremely strong. It has to be strong to overcome the electric repulsion between the positively charged protons. It is also of very short range, acting only when two particles are within 1 or 2 fm of each other.

1 fm (femto meter) = 10^{-15} m = 10^{-15} m = 0.000000000000001 meters.

The qualitative features of the nucleon-nucleon force are shown below.



There is an extremely **strong short-range repulsion** that pushes protons and neutrons apart before they can get close enough to touch. (This is shown in orange.) This repulsion can be understood to arise because the quarks in individual nucleons are forbidden to be in the same area by the Pauli Exclusion Principle.

There is a **medium-range attraction** (pulling the neutrons and protons together) that is strongest for separations of about 1 fm. (This is shown in gray.) This attraction can be understood to arise from the exchange of quarks between the nucleons, something that looks a lot like the exchange of a pion when the separation is large.

The density of nuclei is limited by the short range repulsion. The maximum size of nuclei is limited by the fact that the attractive force dies away extremely quickly (exponentially) when nucleons are more than a few fm apart.

Elements beyond uranium (which has 92 protons), particularly the trans-fermium elements (with more than 100 protons), tend to be unstable to fission or alpha decay because the Coulomb repulsion between protons falls off much more slowly than the nuclear attraction. This means that each proton sees repulsion from every other proton but only feels an attractive force from the few neutrons and protons that are nearby -- even if there is a large excess of neutrons.

Some "super heavy nuclei" (new elements with about 114 protons) might turn out to be stable as a result of the same kind of quantum mechanical shell-closure that makes noble gases very stable chemically. [7]

Conclusions

This discovery has wide ramifications, as a cosmological magnetic field could play an important role in the formation of the first stars and could seed the stronger field seen in galaxies and clusters of galaxies in the present day. [11]

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Warwick Ph.D. student Daniel Craik, who worked on the study, adds "Perhaps the most exciting part of this new result is that it could be the first of many similar discoveries with LHC data. Whether we can use the same technique, as employed with our research into Ds3*(2860), to also improve our understanding of the weak interaction is a key question raised by this discovery. If so, this could help to answer one of the biggest mysteries in physics: why there is more matter than antimatter in the Universe."

Lattice QCD gives the same results as the diffraction theory of the electromagnetic oscillators, which is the explanation of the strong force and the quark confinement. [8]

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References

[1] The Magnetic field of the Electric current and the Magnetic induction

http://academia.edu/3833335/The_Magnetic_field_of_the_Electric_current

[2] 3 Dimensional String Theory

http://academia.edu/3834454/3_Dimensional_String_Theory

[3] Color confinement - Wikipedia, the free encyclopedia
http://en.wikipedia.org/wiki/Color_confinement

[4] *INTRODUCTION TO LATTICE QCD*

http://arxiv.org/abs/hep-lat/9807028

[5] QCD http://en.wikipedia.org/wiki/Quantum_chromodynamics

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

[7]
http://www.cartage.org.lb/en/themes/sciences/physics/NuclearPhysics/WhatisNuclear/Forces/Forces.htm

[8] Theory of Everything

http://www.academia.edu/4168202/Theory_of_Everything_-_4_Dimensional_String_Theory

[9] New subatomic particle sheds light on fundamental force of nature

http://www.spacedaily.com/reports/Discovery_of_new_subatomic_particle_sheds_light_on_fundamental_force_of_nature_999.html

[10] Physicists closer to understanding balance of matter, antimatter in universe

http://www.sciencedaily.com/releases/2014/10/141027145008.htm?utm_content=bufferb15e6&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer

[11] Left-handed cosmic magnetic field could explain missing antimatter

http://www.sciencedaily.com/releases/2015/05/150514085655.htm

[12] New Study Achieves Breakthrough in Antimatter Research

http://futurism.com/new-study-achieves-breakthrough-in-antimatter-research/