Antiproton's Magnetic Moment and Baryonic Asymmetry

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The fact that the neutron is slightly more massive than the proton is the reason why atomic nuclei have exactly those properties that make our world and ultimately our existence possible. Eighty years after the discovery of the neutron, a team of physicists from France, Germany, and Hungary headed by Zoltán Fodor, a researcher from Wuppertal, has finally calculated the tiny neutron-proton mass difference. [9]

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.

Contents

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Preface

The fact that the neutron is slightly more massive than the proton is the reason why atomic nuclei have exactly those properties that make our world and ultimately our existence possible. Eighty years after the discovery of the neutron, a team of physicists from France, Germany, and Hungary headed by Zoltán Fodor, a researcher from Wuppertal, has finally calculated the tiny neutron-proton mass difference. The findings, which have been published in the current edition of Science, are considered a milestone by many physicists and confirm the theory of the strong interaction. As one of the most powerful computers in the world, JUQUEEN at Forschungszentrum Jülich was decisive for the simulation. [10]

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!

Improved measurements of antiproton's magnetic moment deepen mystery of baryonic asymmetry

One of the deepest mysteries of physics today is why we seem to live in a world composed only of matter, while the Big Bang should have created equal amounts of matter and antimatter. Around the world, scientists including Stefan Ulmer's team from RIKEN, are designing and carrying out high-precision measurements to try to discover fundamental dissimilarities between matter and antimatter that could lead to the discrepancy.

In work published in Nature Communications, Ulmer's team has found that the magnetic moment of the antiproton is extremely close to that of the proton. The researchers used a sophisticated technique with six-fold higher accuracy than previously, which involves trapping individual particles in a magnetic device.

To perform the experiments, they took antiprotons generated by CERN's Antiproton Decelerator and placed them into a powerful magnetic device—called a Penning trap—where they could be stored for periods of more than a year. When doing the measurements—at times carefully chosen to fall during night shifts or on weekends to minimize magnetic interference—they took individual antiprotons from the containment trap and moved them into another trap, where they were cooled to nearly absolute zero and placed into a powerful and complex magnetic field, allowing the group to measure the magnetic moment.

Based on six measurements done using this method, the group found that the moment (g-factor) of the antiproton is 2.7928465(23), while that of the proton was previously found to be 2.792847350(9)—with the number in parentheses indicating the amount of uncertainty in the final digits. This puts the two measurements—which are both absolute, rather than relative ones—to within 0.8 parts per million of one another.

According to Ulmer, "We see a deep contradiction between the standard model of particle physics, under which the proton and antiproton are identical mirror images of one another, and the fact that on cosmological scales, there is an enormous gap between the amount of matter and antimatter in the universe. Our experiment has shown, based on a measurement six times more precise than any done before, that the standard model holds up, and that there seems, in fact, to be no difference in the proton/antiproton magnetic moments at the achieved measurement uncertainty. We did not find any evidence for CPT violation."

In future experiments, the team plans to target the application of an even more sophisticated double Penning trap technique. With this method, 1000-fold improved measurements are possible. The group has already applied this technique to measure the proton magnetic moment and has the set of required methods at hand to conduct this measurement with the antiproton as well. "However, the implementation of this experimental scheme is technically very challenging, and will require several iterations", says Hiroki Nagahama, a Ph.D. student in Ulmer's group and first author of the study. "We are planning to conduct this measurement in one of the next antiproton runs." [13]

Non-invasive intensity measurements of low energy beams demonstrated for the first time

A precise measurement of absolute beam intensity is a key parameter to monitor any losses in a beam and to calibrate the absolute number of particles delivered to the experiments.

However, this type of measurement is very challenging with traditional beam current diagnostics when it comes to low-energy, low-intensity beams due to the very low signal levels. Particle accelerator experts from the University of Liverpool have now experimentally demonstrated a new type of monitor in a collaboration with CERN, the GSI Helmholtz Centre for Heavy Ion Research and Friedrich Schiller University and Helmholtz Institute Jena.

A paper just published in Superconducting Science and Technology documents the challenges of implementation and first beam measurements. These are the first-ever measurements of this type performed in a synchrotron using both coasting and short-bunched beams.

The Antiproton Decelerator (AD) is a synchrotron that provides low-energy antiprotons for studies of antimatter. These studies rely on creating antimatter atoms (such as anti-hydrogen) and using them as probes for the most fundamental symmetries in nature such as the invariance of CPT, or of the gravitational acceleration on matter and antimatter.

A precise measurement of the beam intensity in the AD is essential to monitor any losses during the deceleration and cooling phases of the AD cycle, and to calibrate the absolute number of particles delivered to the experiments. However, this is very challenging with traditional beam current diagnostics due to the low intensity of the antiproton beam, which is of the order of only 10 million particles, corresponding to beam currents as low as a few hundred nano-amperes. To cope with this, a Cryogenic Current Comparator (CCC) based on a superconducting quantum interference device (SQUID) was developed and installed in the AD, in a collaboration between accelerator experts from the University of Liverpool and CERN, the GSI Helmholtz Centre for Heavy Ion Research, Friedrich Schiller University and the Helmholtz Institute Jena.

Previous incarnations of CCCs for accelerators suffered from issues concerning sensitivity to mechanical vibrations and electromagnetic perturbations. Furthermore, these setups were used for measuring slow beams, usually from transfer lines of accelerators, and were unable to measure short bunched beams presenting fast current variations. In order to measure the beam current and intensity throughout the cycle of a synchrotron machine such as the AD, the CCC needed to be adapted to cope with the fast signals of bunched beams.

In an open access paper just published in the IOP Superconducting Science and Technology journal, Miguel Fernandes and co-authors describe the challenges of implementation and first beam measurements. These are the first-ever CCC beam current measurements performed in a synchrotron using both coasting and short bunched beams. The paper demonstrates the exciting prospects of this new type of beam diagnostics device. [12]

CERN experiment improves precision of antiproton mass measurement with new innovative cooling technique

In a paper published today in the journal Science, the ASACUSA experiment at CERN reported new precision measurement of the mass of the antiproton relative to that of the electron. This result is based on spectroscopic measurements with about 2 billion antiprotonic helium atoms cooled to extremely cold temperatures of 1.5 to 1.7 degrees above absolute zero. In antiprotonic helium atoms an antiproton takes the place of one of the electrons that would normally be orbiting the nucleus.

Such measurements provide a unique tool for comparing with high precision the mass of an antimatter particle with its matter counterpart. The two should be strictly identical.

"A pretty large number of atoms containing antiprotons were cooled below minus 271 degrees Celsius. It's kind of surprising that a 'half-antimatter' atom can be made so cold by simply placing it in a refrigerated gas of normal helium," said Masaki Hori, group leader at the ASACUSA collaboration.

Matter and antimatter particles are always produced as a pair in particle collisions. Particles and antiparticles have the same mass and opposite electric charge. The positively charged positron, for example, is an anti-electron, the antiparticle of the negatively charged electron. Positrons have been observed since the 1930s, both in natural collisions from cosmic rays and in particle accelerators. They are used today in hospital in PET scanners. However, studying antimatter particles with high-precision remains a challenge because when matter and antimatter come into contact, they annihilate – disappearing in a flash of energy.

CERN's Antiproton Decelerator is a unique facility delivering low-energy antiproton beams to experiments for antimatter studies. In order to make measurements with these antiprotons, several experiments trap them for long periods using magnetic devices. ASACUSA's approach is different as the experiment is able to create very special hybrid atoms made of a mix of matter and antimatter: these are the antiprotonic helium atoms composed of an antiproton and an electron orbiting a helium nucleus. They are made by mixing antiprotons with helium gas. In this mixture, about 3% of the antiprotons replace one of the two electrons of the helium atom. In antiprotonic helium, the antiproton is in orbit around the helium nucleus, and protected by the electron cloud that surrounds the whole atom, making antiprotonic helium stable enough for precision measurements.

Latest precision measurement of the mass of the proton and the anti proton though the production of antiprotonic helium by the ASACUSA experiment at CERN's antimatter factory, with a beam from the Antiproton Decelerator 00:03:41.480 / 02 November 2016. Credit: CERN (License: Julien Ordan)

The measurement of the antiproton's mass is done by spectroscopy, by shining a laser beam onto the antiprotonic helium. Tuning the laser to the right frequency causes the antiprotons to make a quantum jump within the atoms. From this frequency the antiproton mass relative to the electron mass can be calculated. This method has been successfully used before by the ASACUSA collaboration to measure with high accuracy the antiproton's mass. However, the microscopic motion of the antiprotonic helium atoms introduced a significant source of uncertainty in previous measurements.

The major new achievement of the collaboration, as reported in Science, is that ASACUSA has now managed to cool down the antiprotonic helium atoms to temperatures close to absolute zero by suspending them in a very cold helium buffer-gas. In this way, the microscopic motion of the atoms is reduced, enhancing the precision of the frequency measurement. The measurement of the transition frequency has been improved by a factor of 1.4 to 10 compared with previous experiments. Experiments were conducted from 2010 to 2014, with about 2 billion atoms, corresponding to roughly 17 femtograms of antiprotonic helium.

According to standard theories, protons and antiprotons are expected to have exactly the same mass. To date, no difference has been found between their masses, but pushing the precision limits of this comparison is a very important test of key theoretical principles such as the CPT symmetry. CPT is a consequence of basic symmetries of space-time, such as its isotropy in all directions. The observation of even a minute breaking of CPT would call for a review of our assumptions about the nature and properties of space-time.

The ASACUSA collaboration is confident that it will be able to further improve the precision of antiproton's mass by using two laser beams. In the near future, the start of the ELENA facility at CERN will also allow the precision of such measurements to be improved. [11]

Exclusive production: shedding light with grazing protons

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As its name implies, the primary mission of the Large Hadron Collider is to generate collisions of protons for study by physicists at experiments such as CMS. It may surprise you to find out that the vast majority of protons accelerated by the LHC never collide with one another. Some of these fly-by protons, however, still interact with each other in such a way as to help physicists shed light on the nature of the universe.

The LHC accelerates bunches of protons, with more than 10 billion protons in each bunch, in opposite directions around the ring. As those protons arrive at a detector, such as CMS, magnets focus the beams to increase the density of protons and thus increase the chance of a coveted collision. Despite what seems like overwhelming odds, only a few of these protons actually collide with each other: tens to hundreds per each beam “crossing.” An even smaller fraction of the remaining protons pass close enough to other protons to “feel” each other, even if they do not directly collide.

Think of two toy magnets on a tabletop: A north end and a south end moved close enough to each other will rather firmly stick to each other. However, you can also move one magnet just close enough to the other that you can make it wiggle without drawing it all the way over. This exchange of energy is mediated by the exchange of photons, the carrier particle of the electromagnetic force. Similarly, two protons in the LHC that get just the right distance from each other will exchange photons without colliding.

Now for the part that gets really interesting to particle physicists. The photons generated by these near-miss proton interactions can be billions of times more energetic than those of visible light, and as a result they carry enough energy to create particles in their own right. The Standard Model predicts the production of massive particles, such as pairs of W bosons, from these interacting photons without any of the additional activity that is seen in the messier proton-proton collision events. In a detector such as CMS, this pair of W bosons is said to be produced “exclusively.” However, “exclusive production” is an apt name in another way – creating a pair of W bosons from interacting photons is a rare occurrence in an even rarer sample of photons generated from near-miss proton interactions.

CMS scientists performed such a search for such W boson pairs emanating from interacting photons. In a data set consisting of 7- and 8-TeV collisions, 15 candidate events for this process were observed. While it may not seem like much, the expected background was considerably smaller, allowing the CMS team to claim that they have evidence of the process. (In the particle physics world, evidence is a three-standard-deviation departure from background, as explained here).

Furthermore, these results helped place stringent results on a number of models which predict a greater rate of this process. [10]

Theory of the strong interaction verified

The findings, which have been published in the current edition of Science, are considered a milestone by many physicists and confirm the theory of the strong interaction. As one of the most powerful computers in the world, JUQUEEN at Forschungszentrum Jülich was decisive for the simulation.

The existence and stability of atoms relies heavily on the fact that neutrons are slightly more mas-sive than protons. The experimentally determined masses differ by only around 0.14 percent. A slightly smaller or larger value of the mass difference would have led to a dramatically different universe, with too many neutrons, not enough hydrogen, or too few heavier elements. The tiny mass difference is the reason why free neutrons decay on average after around ten minutes, while protons - the unchanging building blocks of matter - remain stable for a practically unlimited period.

In 1972, about 40 years after the discovery of the neutron by Chadwick in 1932, Harald Fritzsch (Germany), Murray Gell-Mann (USA), and Heinrich Leutwyler (Switzerland) presented a consistent theory of particles and forces that form the neutron and the proton known as quantum chromodynamics. Today, we know that protons and neutrons are composed of "up quarks" and "down quarks". The proton is made of one down and two up quarks, while the neutron is composed of one up and two down quarks.

Simulations on supercomputers over the last few years confirmed that most of the mass of the proton and neutron results from the energy carried by their quark constituents in accordance with

Einstein's formula E=mc2. However, a small contribution from the electromagnetic field surrounding the electrically charged proton should make it about 0.1 percent more massive than the neutral neutron. The fact that the neutron mass is measured to be larger is evidently due to the different masses of the quarks, as Fodor and his team have now shown in extremely complex simulations.

For the calculations, the team developed a new class of simulation techniques combining the laws of quantum chromodynamics with those of quantum electrodynamics in order to precisely deter-mine the effects of electromagnetic interactions. By controlling all error sources, the scientists successfully demonstrated how finely tuned the forces of nature are.

Professor Kurt Binder is Chairman of the Scientific Council of the John von Neumann Institute for Computing (NIC) and member of the German Gauss Centre for Supercomputing. Both organizations allocate computation time on JUQUEEN to users in a competitive process. "Only using world-class computers, such as those available to the science community at Forschungszentrum Jülich, was it possible to achieve this milestone in computer simulation," says Binder. JUQUEEN was supported in the process by its "colleagues" operated by the French science organizations CNRS and GENCI as well as by the computing centres in Garching (LRZ) and Stuttgart (HLRS). [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) $I = I_0 \sin^2 n\,\phi/2 \,/\, \sin^2 \phi/2$

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

(2) $I = n^2 I_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

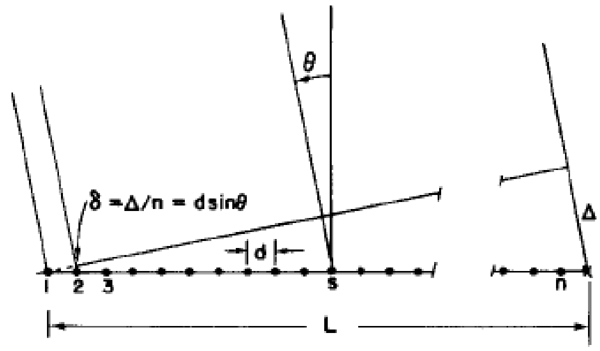


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

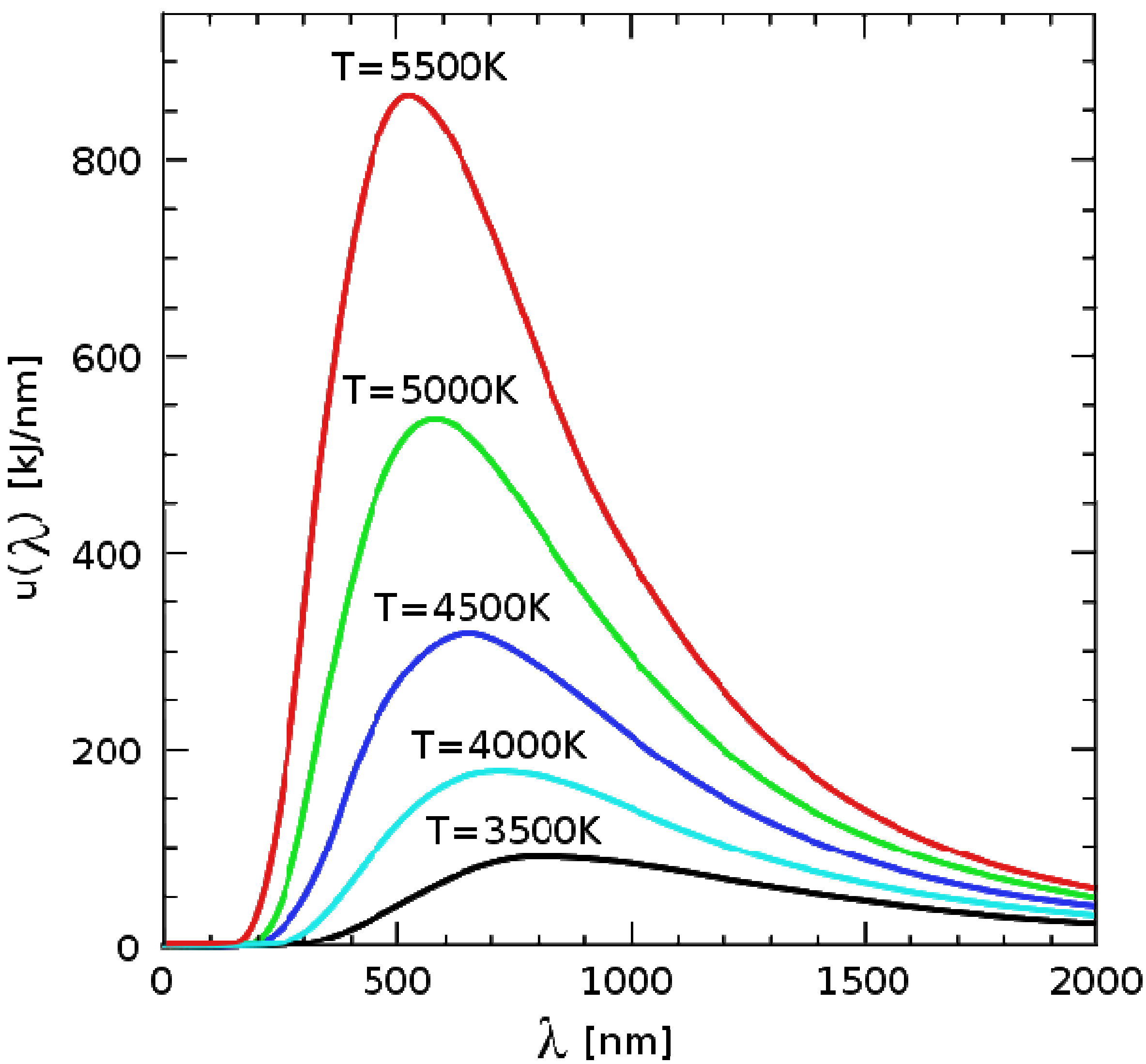


Figure 2. The distribution law for different T temperatures

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]

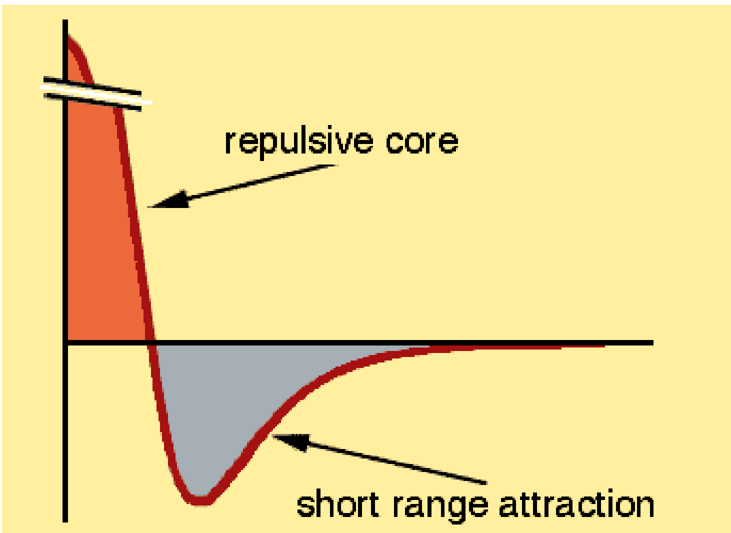
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a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

The results of this work by Fodor's team of physicists from Bergische Universität Wuppertal, Centre de Physique Théorique de Marseille, Eötvös University Budapest, and Forschungszentrum Jülich open the door to a new generation of simulations that will be used to determine the properties of quarks, gluons, and nuclear particles. According to Professor Kálmán Szabó from Forschungszentrum Jülich, "In future, we will be able to test the standard model of elementary particle physics with a tenfold increase in precision, which could possibly enable us to identify effects that would help us to uncover new physics beyond the standard model." [9]

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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