

Colorful Microcosm within a Proton

The proton sounds like a simple object, but it's not. Inside, there's a teeming microcosm of quarks and gluons with properties such as spin and "color" charge that contribute to the particle's seemingly simplistic role as a building block of visible matter. By analyzing the particle debris emitted from collisions of polarized protons at the Relativistic Heavy Ion Collider (RHIC), scientists say they've found a new way to glimpse that internal microcosm. They've measured a key effect of the so-called color interaction-the basis for the strong nuclear force that binds quarks within the proton. This new measurement tests, for the first time, theoretical concepts that are essential for mapping the proton's three-dimensional internal structure. [11]

A team of physicists suggested that the fundamental building unit proton can alter its structure under certain circumstances. Scientists are now performing experiments to show that the structure of protons can change inside the nucleus under certain conditions. [10]

Exotic Mesons and Hadrons are high energy states of Quark oscillations.

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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A view of the colorful microcosm within a proton

The proton sounds like a simple object, but it's not. Inside, there's a teeming microcosm of quarks and gluons with properties such as spin and "color" charge that contribute to the particle's seemingly simplistic role as a building block of visible matter. By analyzing the particle debris emitted from collisions of polarized protons at the Relativistic Heavy Ion Collider (RHIC), scientists say they've found a new way to glimpse that internal microcosm. They've measured a key effect of the so-called color interaction—the basis for the strong nuclear force that binds quarks within the proton. This new measurement tests, for the first time, theoretical concepts that are essential for mapping the proton's three-dimensional internal structure.

The research, described in a paper to be published as an Editor's Suggestion in Physical Review Letters, is only possible at RHIC, a 2.4-mile circular particle collider that operates as a U.S. Department of Energy (DOE) Office of Science User Facility for nuclear physics research at DOE's Brookhaven National Laboratory. RHIC is unique in that it uses specialized magnets to strategically align the spins of billions of tiny protons so they are mostly pointing in a particular direction as they circulate and collide.

This adjustable polarization is essential for teasing out details of the particles' internal structure, including how their constituent quarks and glue-like binding particles called gluons contribute to the protons' overall spin, and how these particles interact.

"In this experiment, the polarization gives scientists a unique way to understand hard-to-catch details of how the 'color' charges of quarks and gluons affect their microcosmic interactions," explained Brookhaven physicist Elke Aschenauer, a member of the scientific collaboration using RHIC's STAR detector to analyze the subatomic smashups.

If you've ever seen the colorful images of particle tracks emerging from collisions at STAR, you might wonder what all the fuss over "color" is about. STAR has been producing these firework-like displays since RHIC started operating in June 2000. The colors of those tracks help identify the types of particles emerging from RHIC collisions. But the "color" of the quarks that make up the colliding ions is a rather different concept. It's a type of charge that borrows a naming convention from our understanding of visible light because it comes in three forms that must be combined to form a neutral state-similar to the way the three primary colors of light (red, green, and blue) combine to form "neutral" white light.

As is the case with more-familiar positive and negative electric charges, in color charge, opposites attract and like charges repel.

"To get neutral (white) you need all three colors. So the opposite of each individual color charge is the other two combined," Aschenauer said.

The need for three differently colored quarks to combine is the defining property of the strong nuclear force-which makes it impossible for quarks to be free, and ultimately binds protons and neutrons to form the atoms of visible matter. While several experiments have sought to measure the effects of the attractive interaction that binds "unlike" color charges, scientists have now, for the first time, measured an effect of the repulsive color interaction when "like" color charges meet up in particle collisions at RHIC.

Same asymmetry, opposite sign

Probing the effects of color charge interactions in particle collisions at STAR is no easy task. As STAR collaborator Salvatore Fazio explained, the RHIC physicists do it by measuring the number, trajectory, and energy level of particles called W bosons that emerge from RHIC's collisions of polarized protons. But Ws decay in a flash-into an electron, which is fairly easy to pick up, and a neutrino, a notoriously elusive particle that quickly escapes. To get a read on the neutrino's energy, the scientists must detect all the particles that recoil in the opposite direction from the escaping neutrino-then add all that together with the energy of the electron to get the information they need about each W.

This reconstruction of a particle from a jet-like spray of debris requires a big detector with a very large acceptance-the ability to track a wide variety of particles over a very large area. In other words, you need STAR, a tracking detector that, like a giant barrel, covers the region around the point where the beams collide and is capable of catching thousands of particle sprays per second.

"The details about this measurement are very technical," Fazio said, "but counting up all the Ws can point to something called a 'single transverse spin asymmetry'-an imbalance in the number of these particles emerging to one side of the detector compared to the other depending on where the spin of the proton is pointing." This measurement is a big step toward verifying a long-standing theoretical prediction based on insights into the workings of the color interaction.

As Aschenauer pointed out, "There are a lot of initiatives in the world to measure this asymmetry in electron- or muon-proton collisions, using fixed targets at other facilities such as COMPASS, HERMES, and Thomas Jefferson National Accelerator Facility. But all the measurements from those experiments reflect the effects of the attractive force between 'unlike' color charges. The only way

to test the theory of the color interaction being in one case attractive and in the other repulsive is to have an observable that is driven by the repulsive interaction between 'like' color charges-which is what we were able to test with polarized proton-proton collisions at RHIC."

The hypothesis was that the RHIC experiment would produce the same spatial imbalance in W production, but in the opposite direction as seen in the experiments sensitive to the interactions of "unlike" color charges. The experimental test of this "sign change" is one of the open questions in hadronic physics and was recently noted as a priority by the nation's Nuclear Science Advisory Committee (NSAC).

Even after conducting these studies for a relatively short time as a way to prove the concept, the STAR team says they've seen a hint of the sign change, but more data are needed to be sure.

"Because it is such a complicated measurement, we initially did not dedicate an entire run to this. But now we do have a hint we want to pursue," Fazio said. The team hopes to nail the case in the RHIC run of 2017, which for STAR, will be dedicated to this measurement.

In addition, because these new findings align with the theory scientists have been using to describe the inner structure of the proton, they also support their plan to use future collisions of electrons with polarized protons at a proposed electron ion collider (EIC) to conduct detailed studies of the internal structure of the proton.

"These STAR measurements give an indication of the internal momentum of quarks and gluons, both in the direction of motion but also transverse momentum. An EIC would unravel all the necessary details to produce 3D pictures of the proton's momentum structure," Aschenauer said. [11]

Physicists Are About To Test A Hypothesis That Could Rewrite The Textbooks

A team of physicists suggested that the fundamental building unit proton can alter its structure under certain circumstances. Scientists are now performing experiments to show that the structure of protons can change inside the nucleus under certain conditions. If they become successful, all the current studies are going to be reviewed. Anthony Thomas and his team have published their results in Physical Review Letters. The experiments, which are currently underway in the US, aim to prove that the structure of protons can change inside the nucleus of an atom under certain conditions. If that's found to be the case, a whole lot of experiments are going to have to be reassessed.

The researcher, Anthony Thomas said "The idea that the internal structure of protons might change under some specific conditions seems to be ridiculous, for most of the scientists. While for others like me, indication of this internal change is highly pursued and would help to explicate some of the uncertainties in theoretical physics". This study has certain insinuations in the fields of nuclear and theoretical physics. Protons are one of the smallest building blocks, made up of small particles known as quarks, bound together by gluons. They consider that the protons present inside the nuclei of atoms don't have a fix structure.

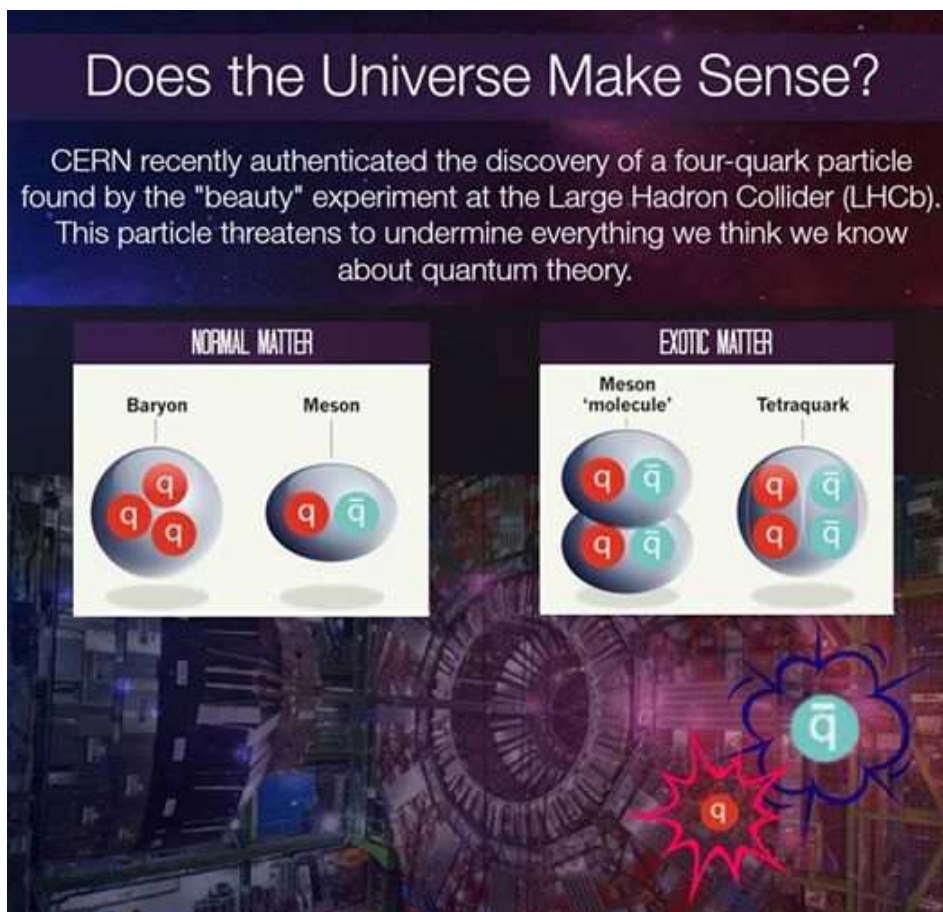
But this concept seems not to satisfy the theory that explains relation between quarks and gluons named as Quantum Chromodynamics.

Thomas said “By bombarding the beam of electrons at an atomic nucleus, we can evaluate the difference in energy of the outgoing electrons. Now we are looking forward for the appropriate outcomes.”

Thomas also said “The results are substantial for us. This could put forward a new concept for nuclear physics”.

Whether their predictions are correct or not, the consequences are going to add a huge breakthrough in our notions regarding the fundamental building blocks – protons. And will give rise to some better concepts about the chemistry of everything around us. [10]

How a New Discovery in the World of Quarks Could Change Everything



In 2013, scientists announced the discovery of Zc(3900): the first confirmed particle made of four quarks. Ultimately, quarks, other than being part of our namesake, are the infinitesimally small building blocks of most of the matter in the universe. Previously we had no models to describe this kind of particle, so this new discovery was kind of a big deal.

Since the initial announcement in 2013, the BESIII collaboration - the team responsible for the find – has made “a rapid string of related discoveries” on the topic of four-quark particles. In fact, it seems

that physicists are on the verge of having to create a new classification system to explain how these exotic particles fit into the equation, especially now that the findings have been confirmed.

This will likely require a lot of work. You see, quarks have long been known to pair together in groups of twos and threes. When we have two quark particles, they are known as “mesons,” and three quark particles are known as “baryons.” You are probably rather familiar with the latter (even if you don’t realize it), as baryons make up both protons and neutrons, the building blocks that constitute every atom in your body and everything else around you; hence, why this discovery is of so much importance.

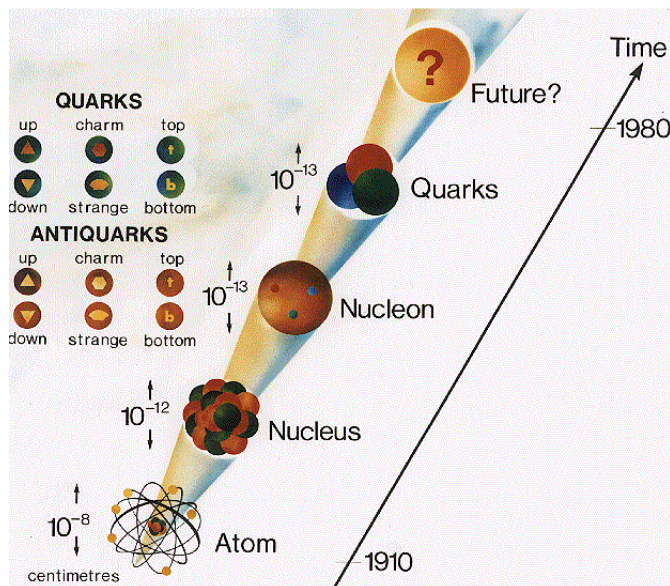
Today, we wanted to revisit some of the implications of these new four quark particles.

So we have a less-than-perfect model of quark particles, and since (as previously mentioned) they make up matter, an accurate model has broad reaching implications on our understanding of the universe.

Ultimately, this discovery is going to overthrow everything we know about the universe; it is not going to topple the standard model. However, it does force one to stop and consider what other discoveries are waiting for us on the horizon.

Researchers are expected to run decay experiments over the course of this year to determine its nature with more precision. [1]

Digging Deeper



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!

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:

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

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

$$(2) I = n^2 I_0$$

This gives us the idea of

$$(3) M_p = n^2 M_e$$

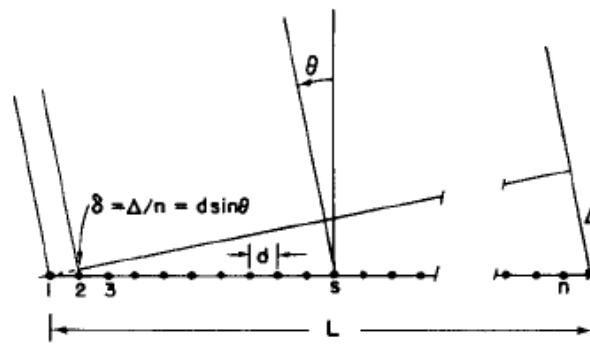


Fig. 30-3. A linear array of n equal oscillators, driven with phases $\alpha_s = s\alpha$.

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

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

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

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

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 $d_p < \lambda_e$ 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:

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

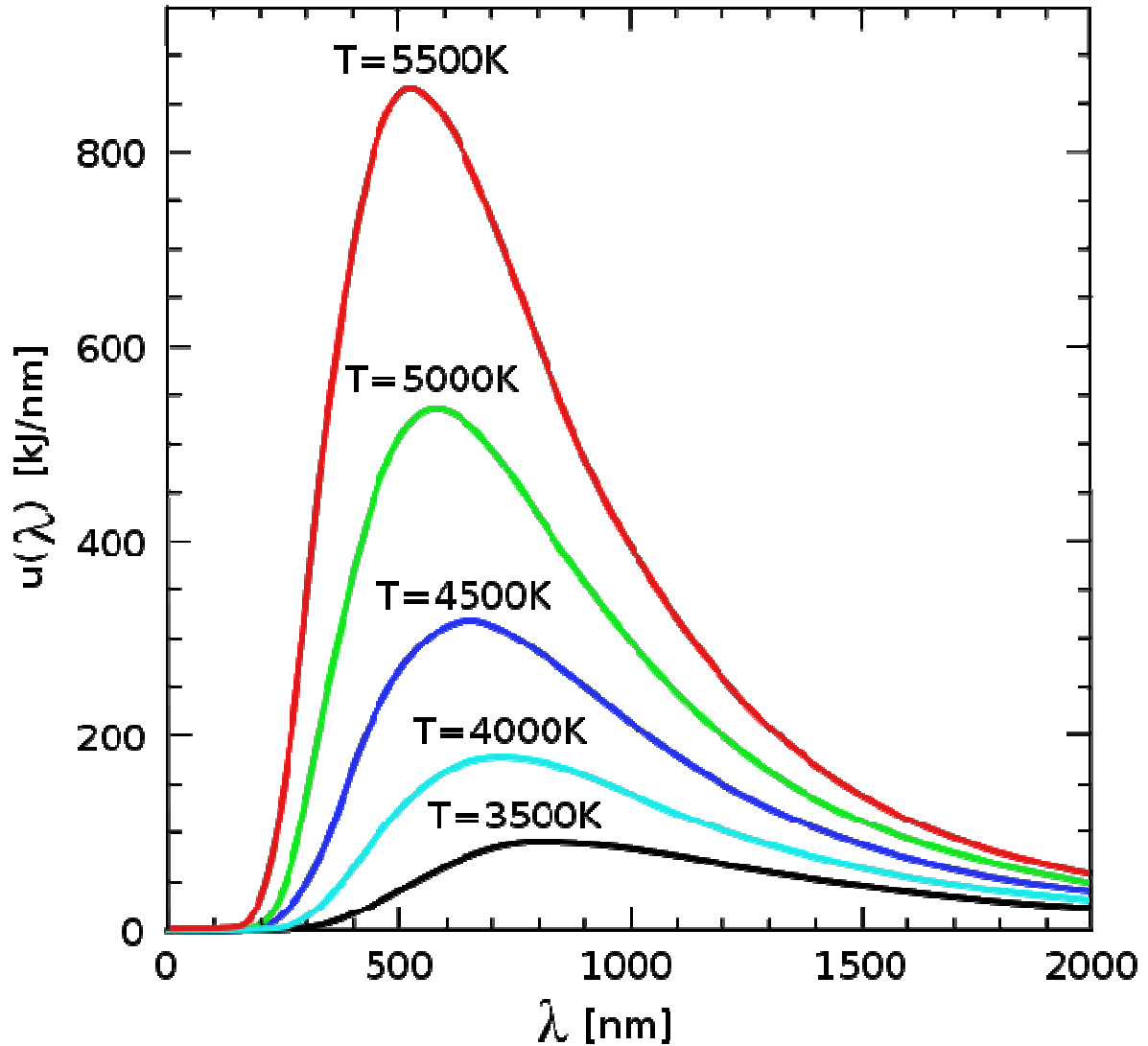


Figure 2. The distribution law for different T temperatures

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.

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

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 $2.8977685(51) \times 10^{-3} \text{ m} \cdot \text{K}$ (2002 CODATA recommended value).

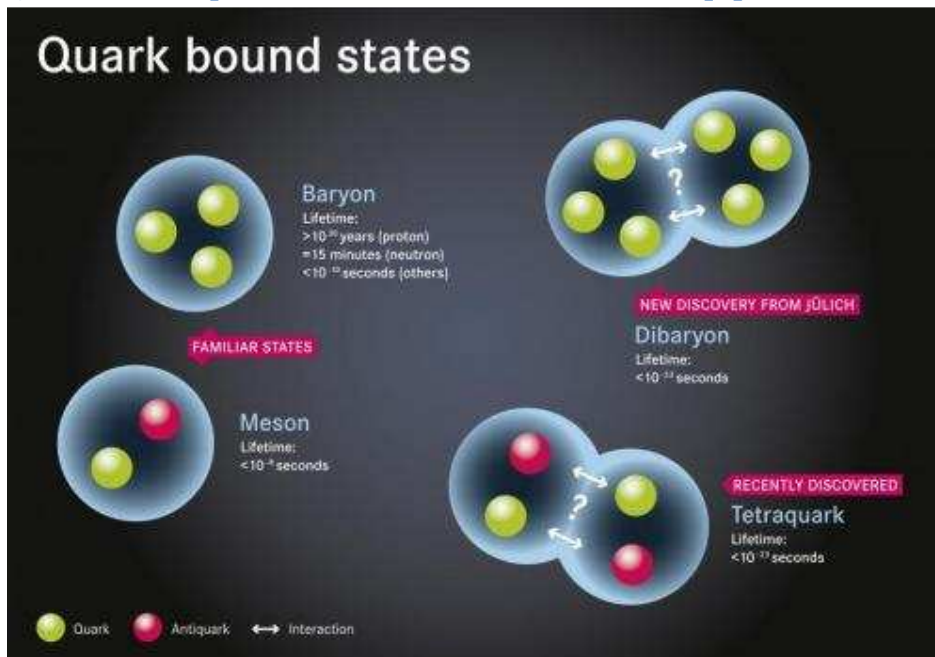
By the changing of T the asymmetrical configurations are changing too.

The structure of the proton and deuteron

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 an asymptotic freedom while their energy are increasing to turn them to the orthogonally. 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.

Quarks in six-packs: Exotic Particle Confirmed [9]



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 1/2 spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with $\frac{1}{2}$ 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 $\frac{1}{2}$ 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 α_s 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 $E = h\nu$ and $E = mc^2$, $m = h\nu / c^2$ that is the m depends only on the ν frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_0 inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

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

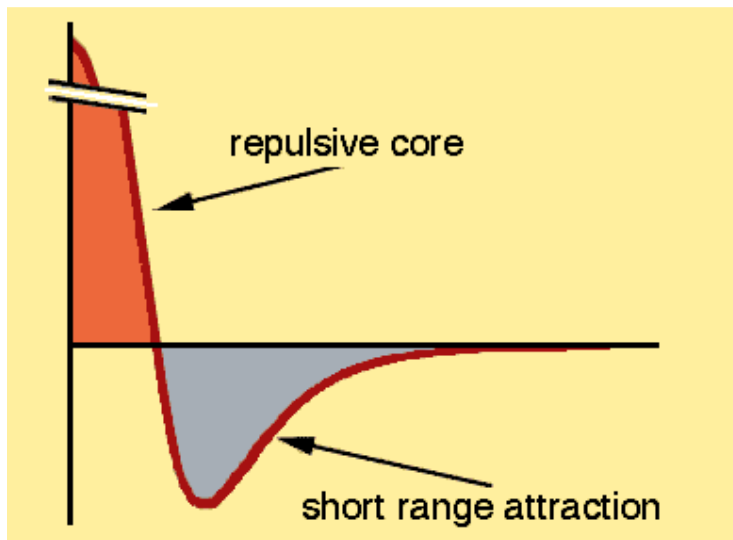
these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

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]

Exotic Mesons and Hadrons

Exotic Mesons and Hadrons are high energy diffraction patterns of the electromagnetic oscillations. They aren't brake the Electro-Strong Interaction barriers and with a complete agreement with this theory.

Conclusions

The Electro-Strong Interaction gives an explanation of the Exotic Mesons and Hadrons. 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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