Sigma of Strong Force

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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.

Contents

Author: George Rajna

Eavesdropping on the particular chatter on the sub-atomic world

Much like two friendly neighbors getting together to chat over a cup of coffee, the minuscule particles in our sub-atomic world also come together to engage in a kind of conversation. Now, nuclear scientists are developing tools to allow them to listen in on the particles' gab fests and learn more about how they stick together to build our visible universe.

Jozef Dudek is a staff scientist at the U.S. Department of Energy's (DOE) Jefferson Lab and an assistant professor of physics at William & Mary. He and his colleagues recently carried out the first complex calculations of a particle called the sigma. They published the result in Physical Review Letters in January.

"The sigma is often thought of as being part of the force that holds protons and neutrons together in the nucleus," Dudek explained. "You can think of there being a force between a proton and a neutron, which is due to the exchange of particles between them. One of the particles that a proton and a neutron may exchange is the sigma."

This exchange of sigma particles by protons and neutrons allows them to communicate through the strong force. The strong force is the force of nature that binds protons and neutrons into nuclei. In fact, the strong force is also responsible for the formation of protons and neutrons.

In decades of delving deep inside the heart of matter to uncover its building blocks, nuclear physicists so far have found that the smallest bits of matter are quarks. It takes three quarks to build a proton (and three to build a neutron). These quarks are bound together by the strong force, again through a conversation between quarks that manifests as the exchange of particles. In this case, the quarks swap strong-force 'glue'—particles called gluons.

So, if particles are able to converse via the exchange of strong force gluons directly, where does that leave the sigma? It turns out that if a proton and a neutron are really close together, they can hold their conversation with a simple swap of gluons. But in a spacious nucleus, it takes other particles, including the sigma, to converse efficiently.

"At larger distances, it makes sense to think about exchanging mesons between nucleons, where mesons are built out of quarks and gluons themselves, but sort of packaged up into confined packets," Dudek said .

These 'confined packets' may be the sigma, which is a meson built of quarks and gluons, or another meson called the pion, familiar to physicists as a particle that is often found hanging around the nucleus.

To put it all together, protons and neutrons may chat it up via the exchange of gluons at short distances, sigma mesons at medium distances and pions at larger distances.

Calculating the heart of matter

If this all sounds rather complicated, that's because it is. Dudek and his colleagues are the first to calculate the sigma particle directly from the theory that describes the strong force, the particles that interact through this force and the nature of those interactions. This theory is called quantum chromodynamics or simply QCD.

In fact, these calculations were so complicated, supercomputers were required to accomplish the feat.

According to Robert Edwards, a senior staff scientist in Jefferson Lab's Center for Theoretical and Computational Physics, the QCD calculations required the dedicated effort of several supercomputers.

The first part of the calculations were carried out on Titan, a supercomputer based at the Oak Ridge Leadership Computing Facility, a DOE Office of Science User Facility at DOE's Oak Ridge National Laboratory in Tennessee, and the Blue Waters supercomputer at the University of Illinois at Urbana-Champaign.

Edwards said these first calculations were used to develop snapshots of the environment of subatomic particles, or the "vacuum" of space described by QCD.

"The vacuum is not an empty place, it's seething with energy," Edwards explains. "And energy is manifested as electric and magnetic fluctuations, which can be thought of as the glue of the strong force. So, what QCD does is look at the strength of these fields at every point in space."

These snapshots of the fluctuating vacuum can be imagined as the surface of a pond being rained on, with the raindrops causing ripples on the pond. Each snapshot of the surface of the pond corresponds to a snapshot of the vacuum. He said 485 snapshots were generated by the Titan supercomputer.

Watching the scenarios play out

For the second part of the calculations, quarks were added to the snapshot. As quarks move through the vacuum, they respond to their environment. Their possible movements, called "propagators," were computed using the Titan and Blue Waters supercomputers. For each snapshot of the vacuum, 800,000 such propagators were computed.

With the propagators in place, several different scenarios were then posed for how specific quarks will interact with each other as they propagate through time. For each scenario, the supercomputer calculates the probability within the theory of QCD that the quarks are likely to interact that certain way.

"We have to evaluate a quantity called a correlation function. The correlation function says that you have some configuration of quarks, and you're watching the propagation as they go through time," Edwards explains. "This correlation function is effectively measuring the correlation, or its strength, between its initial configuration of quarks and its final configuration of quarks."

Continuing our analogy of the raindrops on the pond, now imagine that a rubber duck has been added to the pond. The correlation function calculations determine how likely it is that the rubber duck will float from one point to another on the pond.

Each of the 485 configurations were simulated many times to determine the probability of each scenario, yielding about 15 million results for comparison. The calculations were carried out on Jefferson Lab's LQCD cluster in the spring and summer of 2016.

Sigma comes to life

After all of the calculations were tallied, the researchers found that if the right quarks are present, the sigma can, indeed, be generated by the strong force.

After decades of catching brief glimpses of the sigma's fleeting existence from the experimental data showing its effects on other subatomic particles, Dudek and Edwards say that this calculation now gives scientists a new way to study this elusive particle.

"It's really a first step toward understanding what the sigma is. Does it really exist within the theory? Apparently, it does," Dudek explained.

The properties of the sigma in their calculations seem to match what scientists have come to expect of the real-world sigma's properties. What's more, now that these calculations have demonstrated that it's feasible to apply supercomputers to calculations of an elusive particle like the sigma, this may well open the door for calculations of other short-lived particles.

"We've demonstrated that we can show it exists within QCD. Now, the questions are: What is it? How is it formed? Why does this thing exist? Is there a way to understand it simply?" Dudek said. "Can we address those questions, now that we have a rigorous technique to study within QCD this object? And that's something for the future."

And studying the elusive sigma may allow researchers their first glimpse at this facet of the strong force that exists only deep inside the heart of matter. It may offer them a chance to eavesdrop, if you will, on the force as it goes about its business of building up our universe. [12]

Viewpoint: Spinning Gluons in the Proton

Particle physics experiments conducted at the CERN, DESY, JLab, RHIC, and SLAC laboratories have revealed that only about 30% of the proton's spin is carried by the spin of its quark constituents [1]. This discovery has inspired a 30-year global program of dedicated experiments and theoretical activity to understand the internal spin structure of the proton. But there are several questions. Why is the quark contribution to the proton's spin so small? How much of the proton's remaining "spin budget" is contributed by gluons, the particles that mediate the strong force between quarks (Fig. 1)? And how much is contributed by orbital angular momentum? Yi-Bo Yang from the University of Kentucky, Lexington, and colleagues now present the first theoretical calculation of the gluon contribution to the proton's spin that uses state-of-the-art computer simulations of quark-gluon dynamics on a spacetime lattice [2]. Their new result suggests that gluon spin constitutes a substantial fraction of the proton's spin.

Protons behave like spinning tops. But unlike the classical spin of a top, the spin of the proton and of other elementary particles is an intrinsic quantum phenomenon. This spin is responsible for many fundamental properties and phenomena, including the proton's magnetic moment and the phases of low-temperature matter.

The proton is described in quantum chromodynamics (or QCD, the theory of quarks and gluons) by an inner core of three confined valence quarks and a sea of virtual quark-antiquark pairs and gluons, all surrounded by a diffuse cloud of virtual pions (light-mass bound states of a quark-antiquark pair). The relativistic motion of all of these particles means that they each carry orbital momentum. The spin of the proton is built up from the intrinsic spin of the valence and sea quarks (each 1/2) and the gluons (spin 1) and their orbital angular momentum, where spin is measured in units of Planck's constant divided by 2p2??. The proton spin puzzle is the challenge to understand how these contributions combine to yield the total spin 1/2 of the proton.

High-energy particle-scattering experiments have found that the quark contribution to the proton (30%) comes entirely from the valence quarks; there's just a very small contribution from the quark-antiquark sea [1]. The quark spin content deduced from these experiments could be so small for several reasons. First, the act of putting a relativistic particle, such as a quark, in a confining cavity, as is the case in the proton, generates some shift of total angular momentum from spin to orbital contributions. Second, gluon spin can screen the total quark spin contribution through a quantum effect called the axial anomaly [3]. Third, a topological effect can delocalize the quark spin inside the proton so that it is, in part, invisible to scattering on individual and localized quarks.

The study of the gluon spin, which is the focus of Yang and colleagues' work, is useful in understanding both its share in the total spin budget and the size of the axial-anomaly effect. Experiments in the last decade at CERN and RHIC have provided valuable information on the proton's gluon spin. The spin and orbital contributions to the proton's spin depend on how deeply one probes inside the proton: what appears as a single valence quark at low resolution emerges at higher resolution as a valence quark surrounded by a sea of quark-antiquark pairs and gluons. These gluons will carry spin and orbital angular momentum. When one probes deeper inside the proton, and thus sees a greater number of gluons, the angular momentum summed over all of the proton's constituent particles is always conserved. At the resolution scale of the experiments, one finds that gluons that carry more than 5% of the proton's regular momentum contribute about

0.2±0.050.2±0.05 units of spin to the spin-1/2 proton [4]. Early QCD-inspired models of the proton's spin structure [5] and an early QCD spacetime lattice calculation [6] had suggested a gluon spin contribution of less than about 1 at the same scale, less accurate than present experiments.

In their study, Yang and co-workers have calculated the gluon spin contribution on a spacetime lattice using state-of-the-art computer simulations of QCD. The lattice calculations involve quarks with realistic small quark masses, close to their physical values, which is a major improvement on earlier work. They find a total gluon spin contribution of about 0.25±0.050.25±0.05 at the same resolution scale as the experiments. Their number comes from gluons carrying the full range of regular momentum in the proton. Gluon spin at this resolution thus contributes about 50% of the proton's spin—a substantial chunk of the total spin budget. This gluon spin contribution is, however, too small to play a major role in screening the size of the quark spin contribution through the axial-anomaly effect.

How does this result fit with our knowledge of the quark spin contribution? QCD-inspired models [7] and lattice calculations [8] of the quark spin contribution suggest a very small contribution from the sea quarks to the proton's spin, in agreement with experiments. The small valence-quark spin contribution can be explained within the best present theoretical errors in terms of a shift of total angular momentum from the valence quarks into orbital angular momentum in the pion cloud. Taken together, the results on the quark and gluon contributions to the proton spin yield a self-consistent picture of the proton's spin, based on the spin of the valence quarks, the gluon spin, orbital angular momentum (including that of the pion cloud), and perhaps an additional topological contribution. It is reassuring that QCD-inspired models, computational lattice calculations, and experimental data for both quarks and gluons give results in the same ballpark. With ever-improving computational power and techniques, one looks forward to having full calculations of the complete quark and gluon spin and orbital contributions to the proton's spin from each theoretical group and lattice technique.

On the experimental side, more accurate information will hopefully follow from the electron-ion collider that is proposed for construction at either Brookhaven National Laboratory or at Jefferson Laboratory in the U.S. This project would allow one to measure the spin contribution from gluons carrying as little as 0.1% of the proton's momentum (a 50-fold improvement over present experiments) with an error of about 0.05, as well as to make detailed studies of observables dependent on quark and gluon orbital angular momentum [9].

This research is published in Physical Review Letters. [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.

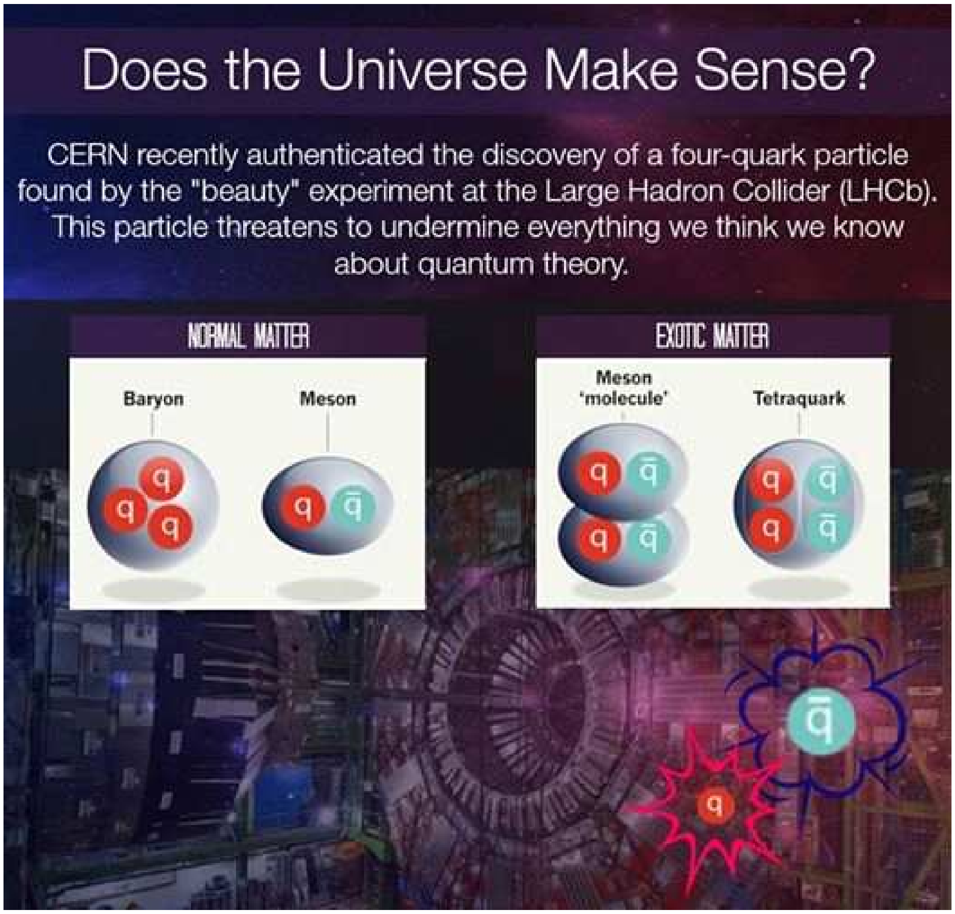
But this concept seems not to satisfy the theory that explains relation between quarks and gluons named as Quantum Chromodynamics.

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 break-through 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 bid 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.

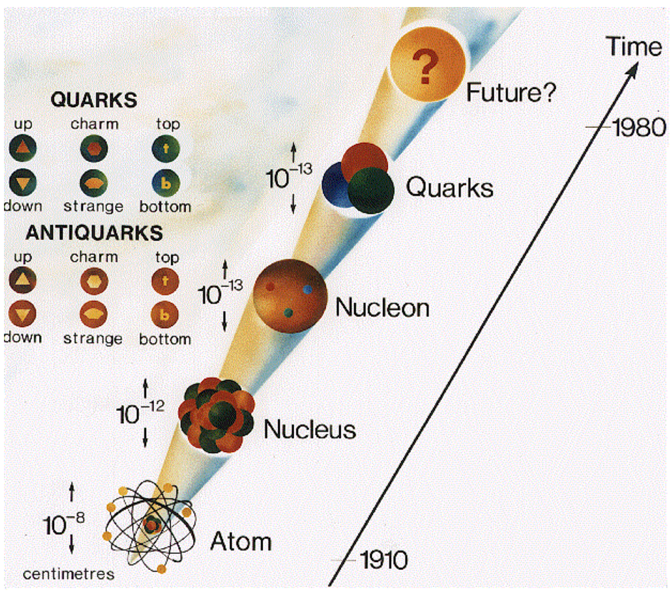
Today, we wanted to revisit some of the implications of these new four quark particles.

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) $I = I_0 \sin^2 n\,\phi/2 \,/\, \sin^2 \phi/2$

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

(2) $I = n^2 I_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

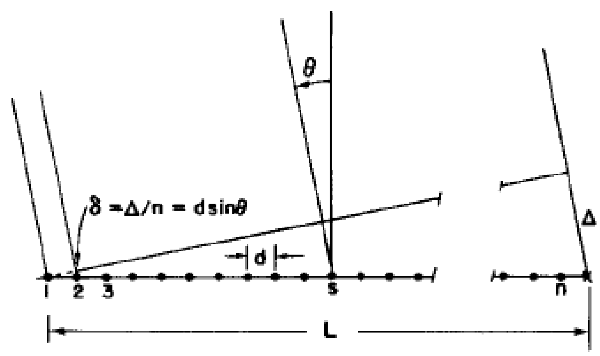


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

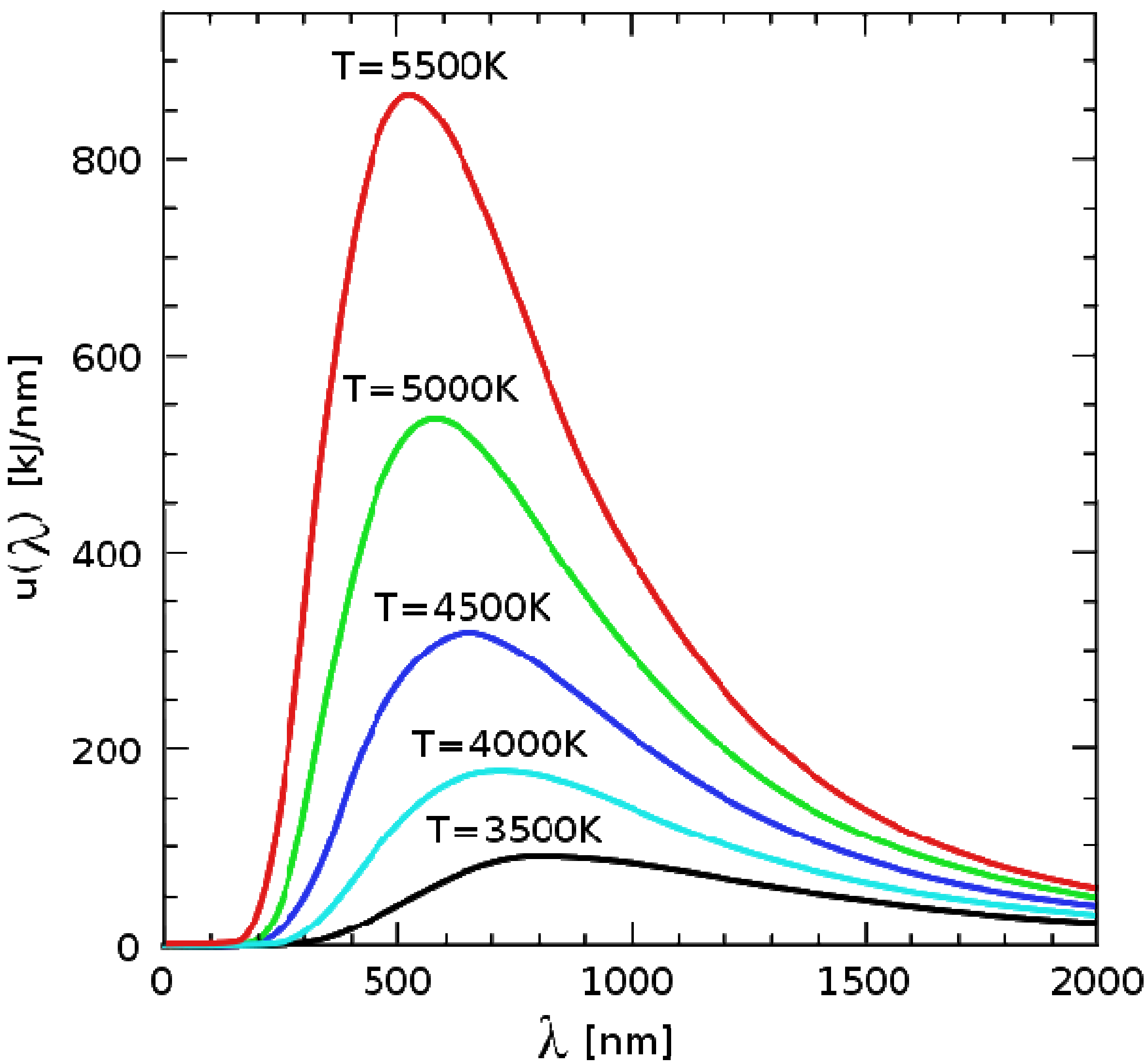


Figure 2. The distribution law for different T temperatures

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).

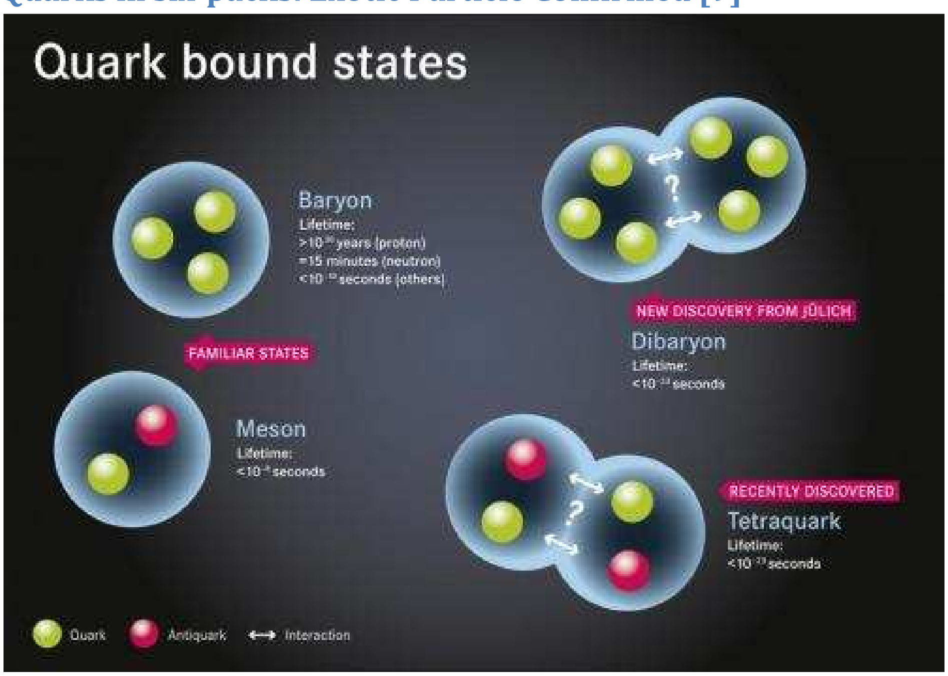
By the changing of T the asymmetrical configurations are changing too.

The structure of the proton 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 1/2spin 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]

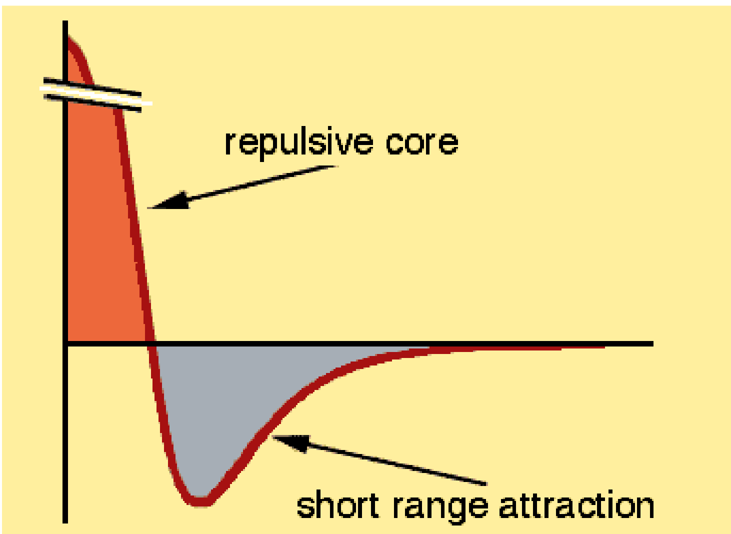
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a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

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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