Quark Soup Critical Point

Thanks to a new development in nuclear physics theory, scientists exploring expanding fireballs that mimic the early universe have new signs to look for as they map out the transition from primordial plasma to matter as we know it. [11]

Now, powerful supercomputer simulations of colliding atomic nuclei, conducted by an international team of researchers including a Berkeley Lab physicist, provide new insights about the twisting, whirlpool-like structure of this soup and what's at work inside of it, and also lights a path to how experiments could confirm these characteristics. [10]

The drop of plasma was created in the Large Hadron Collider (LHC). It is made up of two types of subatomic particles: quarks and gluons. Quarks are the building blocks of particles like protons and neutrons, while gluons are in charge of the strong interaction force between quarks. The new quark-gluon plasma is the hottest liquid that has ever been created in a laboratory at 4 trillion C (7 trillion F). Fitting for a plasma like the one at the birth of the universe. [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.

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Preface

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!

Theory provides roadmap in quest for quark soup 'critical point'

Thanks to a new development in nuclear physics theory, scientists exploring expanding fireballs that mimic the early universe have new signs to look for as they map out the transition from primordial plasma to matter as we know it. The theory work, described in a paper recently published as an Editor's Suggestion in Physical Review Letters (PRL), identifies key patterns that would be proof of the existence of a so-called "critical point" in the transition among different phases of nuclear matter. Like the freezing and boiling points that delineate various phases of water—liquid, solid ice, and steam—the points nuclear physicists seek to identify will help them understand fundamental properties of the fabric of our universe.

Nuclear physicists create the fireballs by colliding ordinary nuclei—made of protons and neutrons—in an "atom smasher" called the Relativistic Heavy Ion Collider (RHIC), a U.S. Department of Energy

Office of Science User Facility at Brookhaven National Laboratory. The subatomic smashups generate temperatures measuring trillions of degrees, hot enough to "melt" the protons and neutrons and release their inner building blocks—quarks and gluons. The collider essentially turns back the clock to recreate the "quark-gluon plasma" (QGP) that existed just after the Big Bang. By tracking the particles that emerge from the fireballs, scientists can learn about nuclear phase transitions—both the melting and how the quarks and gluons "freeze out" as they did at the dawn of time to form the visible matter of today's world.

"We want to understand the properties of QGP," said nuclear theorist Raju Venugopalan, one of the authors on the new paper. "We don't know how those properties might be used, but 100 years ago, we didn't know how we'd use the collective properties of electrons, which now form the basis of almost all of our technologies. Back then, electrons were just as exotic as the quarks and gluons are now."

Changing phases

RHIC physicists believe that two different types of phase changes can transform the hot QGP into ordinary protons and neutrons. Importantly, they suspect that the type of change depends on the collision energy, which determines the temperatures generated and how many particles get caught up in the fireball. This is similar to the way water's freezing and boiling points can change under different conditions of temperature and the density of water molecules, Venugopalan explained.

In low energy RHIC collisions, scientists suspect that while the change in phase from QGP to ordinary protons/neutrons occurs, both distinct states (QGP and ordinary nuclear matter) coexist—just like bubbles of steam and liquid water coexist at the same temperature in a pot of boiling water. It's as if the quarks and gluons (or liquid water molecules) have to stop at that temperature and pay a toll before they can gain the energy needed to escape as QGP (or steam).

In contrast, in higher energy collisions, there is no toll gate at the transition temperature where quarks and gluons must "stop." Instead they move on a continuous path between the two phases.

But what happens between these low-energy and high-energy realms? Figuring that out is now one of the major goals of what's known as the "beam energy scan" at RHIC. By systematically colliding nuclei at a wide range of energies, physicists in RHIC's STAR collaboration are searching for evidence of a special point on their map of these nuclear phases and the transitions between them—the nuclear phase diagram.

At this so-called "critical point," there would be a toll stop, but the cost would be $0, so the quarks and gluons could transition from protons and neutrons to QGP very quickly—almost as if all the water in the pot turned to steam in a single instant. This can actually happen when water reaches its boiling point under high pressure, where the distinction between the liquid and the compressed gas phases blurs to the point of the two being virtually indistinguishable. In the case of QGP, the physicists would expect to see signs of this dramatic effect—patterns in the fluctuations of particles observed striking their detectors—the closer and closer they get to this critical point.

In experiments already conducted at the intermediate energies, STAR physicists have observed such patterns, which may be signs of the hypothesized critical point. This search will continue with increased precision over a wider range of energies during a second beam energy scan, beginning in

2019. The new theoretical work of Brookhaven physicist Swagato Mukherjee, Venugopalan, and former postdoc Yi Yin (now at MIT)—part of a newly funded Beam Energy Scan Theory (BEST) Topical Collaboration in Nuclear Theory—will provide a roadmap to guide the experimental researchers.

Signposts to look for

Certain characteristics of the patterns that occur during phase changes are universal—no matter whether you are studying water, or quarks and gluons, or magnets. But one key advance of the new theory work was using a different set of universal characteristics to account for the dynamic conditions of the expanding quark-gluon plasma.

"All the predictions, the way we started looking for a critical point so far, were based on patterns calculated assuming you have a pot boiling on a stove—a somewhat static system," said Mukherjee. "But QGP is expanding and changing over time. It's more like water boiling as it flows rapidly through a pipe."

To account for the evolving conditions of the QGP in their calculations, the theorists incorporated "dynamic universalities" that were first developed to describe similar pattern formation in the cosmological expansion of the universe itself.

"These ideas have since been applied to other systems like liquid helium and liquid crystals," Venugopalan said. "Yin realized that the specific mechanisms of dynamic universality identified in cosmology and condensed matter systems can be applied to the search for the critical point in heavy ion collisions. This paper is the first explicit demonstration of this conjecture."

Specifically, the paper predicts exactly what patterns to look for in the data—patterns in how the properties of particles emitted from the collisions are correlated—as the energy of the collisions changes.

"If the STAR collaboration looks at the data in a particular way and sees these patterns, they can claim without any ambiguity that they have seen a critical point," Venugopalan said. [11]

Simulations show swirling rings, whirlpool-like structure in subatomic 'soup'

At its start, the universe was a superhot melting pot that very briefly served up a particle soup resembling a "perfect," frictionless fluid. Scientists have recreated this "soup," known as quark-gluon plasma, in high-energy nuclear collisions to better understand our universe's origins and the nature of matter itself. The physics can also be relevant to neutron stars, which are the extraordinarily dense cores of collapsed stars.

Now, powerful supercomputer simulations of colliding atomic nuclei, conducted by an international team of researchers including a Berkeley Lab physicist, provide new insights about the twisting, whirlpool-like structure of this soup and what's at work inside of it, and also lights a path to how experiments could confirm these characteristics. The work is published in the Nov. 1 edition of Physical Review Letters.

Matter, deconstructed

This soup contains the deconstructed ingredients of matter, namely fundamental particles known as quarks and other particles called gluons that typically bind quarks to form other particles, such as the protons and neutrons found at the cores of atoms. In this exotic plasma state—which can reach trillions of degrees Fahrenheit, hundreds of thousands of times hotter than the sun's core—protons and neutrons melt, freeing quarks and gluons from their usual confines at the center of atoms.

These record-high temperatures have been achieved by colliding gold nuclei at Brookhaven National Laboratory's RHIC (Relativistic Heavy Ion Collider), for example, and lead nuclei at CERN's LHC (Large Hadron Collider). Experiments at RHIC discovered in 2005 that quark-gluon plasma behaves like a fluid. In addition to gold nuclei, RHIC has also been used to collide protons, copper and uranium. The LHC began conducting heavy-ion experiments in 2014, and has confirmed that the quark-gluon plasma behaves like a fluid.

There remain many mysteries about the inner workings of this short-lived plasma state, which may only have existed for millionths of a second in the newborn universe, and nuclear physicists are using a blend of theory, simulations and experiments to glean new details about this subatomic soup.

Surprising complexity in plasma structure

"In our sophisticated simulations, we found that there is much more structure to this plasma than we realized," said Xin-Nian Wang, a theorist in the Nuclear Science Division at Berkeley Lab who has worked for years on the physics of high-energy nuclear collisions.

When plotted out in two dimensions, the simulations found that slightly off-center collisions of heavy nuclei produce a wobbling and expanding fluid, Wang said, with local rotation that is twisted in a corkscrew-like fashion.

This corkscrew character relates to the properties of the colliding nuclei that created the plasma, which the simulation showed expanding along—and perpendicular to—the beam direction. Like spinning a coin by flicking it with your finger, the simulations showed that the angular momentum properties of the colliding nuclei can transfer spin properties to the quark gluon plasma in the form of swirling, ring-like structures known as vortices.

The simulations showed two of these doughnut-shaped vortices—each with a right-handed orientation around each direction of the separate beams of the colliding nuclei—and also many pairs of oppositely oriented vortices along the longest dimension of the plasma. These doughnut-shaped features are analogous to swirling smoke rings and are a common feature in classical studies of fluids, a field known as hydrodynamics.

The simulations also revealed a patterned outward flow from hot spots in the plasma that resemble the spokes of a wheel. The time scale covered in the simulation was infinitesimally small, Wang said, roughly the amount of time it takes light to travel the distance of 10-20 protons. During this time the wobbling fluid explodes like a fireball, spurting the particle soup outward from its middle more rapidly than from its top.

Any new understanding of quark-gluon plasma properties should be helpful in interpreting data from nuclei-colliding experiments, Wang said, noting that the emergence of several localized doughnut-like structures in the simulations was "completely unexpected."

Unraveling a mystery

"We can think about this as opening a completely new window of looking at quark-gluon plasmas, and how to study them," he said. "Hopefully this will provide another gateway into understanding why this quark-gluon fluid is such a perfect fluid—the nature of why this is so is still a puzzle. This work will benefit not only theory, but also experiments."

The simulations provide more evidence that the quark-gluon plasma behaves like a fluid, and not a gas as had once been theorized. "The only way you can describe this is to have a very small viscosity," or barely any friction, a characteristic of a so-called 'perfect fluid' or 'fundamental fluid,'" Wang said. But unlike a familiar fluid like water, the simulation focuses on a fluid state hundreds of times smaller than a water molecule.

Michael Lisa, a physics professor at Ohio State University who is part of the collaboration supporting the Solenoidal Tracker at RHIC (STAR), said the so-called vorticity or "swirl structure" of this plasma has never been measured experimentally, though this latest theoretical work may help to home in on it. STAR is designed to study the formation and characteristics of the quark-gluon plasma.

"Wang and his collaborators have developed a sophisticated, state-of-the-art hydrodynamic model of the quark-gluon plasma and have identified swirling structures that vary within the fluid itself," he said. "Even more useful is the fact that they propose a method to measure these structures in the laboratory."

Lisa also said there is ongoing analysis work to confirm the simulation's findings in data from experiments at RHIC and the LHC. "It is precisely innovations like this, where theory and experiment collaborate to explore new phenomena, that hold the greatest hope for greater insight into the quark-gluon plasma," he said.

"Many tools have been used to probe the inner working mechanics and symmetry properties of this unique matter," said Zhangbu Xu, a spokesperson for the STAR collaboration and a staff scientist at Brookhaven National Laboratory. He also said that preliminary results from STAR also suggest some spinning motion in the fluid, and the simulation work "adds a new dimension" to this possibility. [10]

Physicists Recreate Substance Similar To The Plasma Believed To Have Existed At The Very Beginning Of The Universe

The first seconds of the universe were filled with a boiling, chaotic inferno. It was packed with a dense plasma: a soup-like fire, made up of some of the tiniest particles in the universe. Unbelievably, physicists have recreated a substance that they think is very similar to this early universe plasma. Albeit, just the tiniest drop.

The drop of plasma was created in the Large Hadron Collider (LHC). It is made up of two types of subatomic particles: quarks and gluons. Quarks are the building blocks of particles like protons and neutrons, while gluons are in charge of the strong interaction force between quarks. The new quark-gluon plasma is the hottest liquid that has ever been created in a laboratory at 4 trillionoC (7 trillionoF). Fitting for a plasma like the one at the birth of the universe.

The plasma was created after a collision between a proton and a lead nucleus. The physicists had always thought that this collision wouldn't produce enough particles (around 1,000) to create a plasma. A collision between two lead nuclei, for comparison, is known to produce plasma but creates twenty times more particles (around 25,000) following collision. However, the results defied their expectations.

“Before the CMS experimental results, it had been thought the medium created in a proton on lead collisions would be too small to create a quark-gluon plasma,” said Quan Wang, a physicist from Kansas University (KU), in a statement. "The analysis presented in this paper indicates, contrary to expectations, a quark-gluon plasma can be created in very asymmetric proton on lead collisions."

“This is the first paper that clearly shows multiple particles are correlated to each other in proton-lead collisions, similar to what is observed in lead-lead collisions where quark-gluon plasma is produced,” added Yen-Jie Lee, from the Michigan Institute of Technology (MIT). “This is probably the first evidence that the smallest droplet of quark-gluon plasma is produced in proton-lead collisions.”

This new research looks at particle physics with a fresh perspective. Instead of counting individual numbers of particles, the plasma forces physicists to look at the behavior of a volume of particles.

There is also speculation that this plasma replicates the conditions of the early universe. “It’s believed to correspond to the state of the universe shortly after the Big Bang,” Wang continued. This plasma is different to other quark-gluon plasma that have been made before now. The interactions in this plasma are extremely strong, which distinguishes it from other plasmas which interact infrequently (like gas particles). This is what makes the researchers think it might be similar to an early universe plasma.

“While we believe the state of the universe about a microsecond after the Big Bang consisted of a quark-gluon plasma, there is still much that we don't fully understand about the properties of quark-gluon plasma.” [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) $M_p = n^2 M_e$

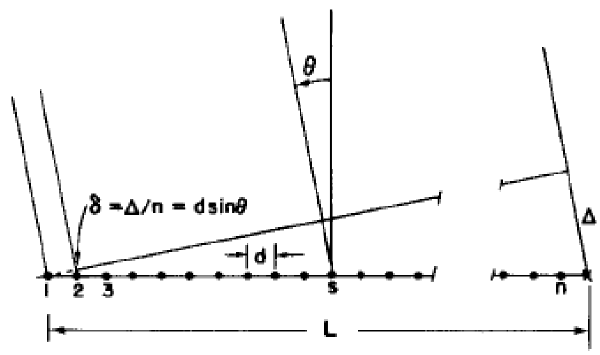


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

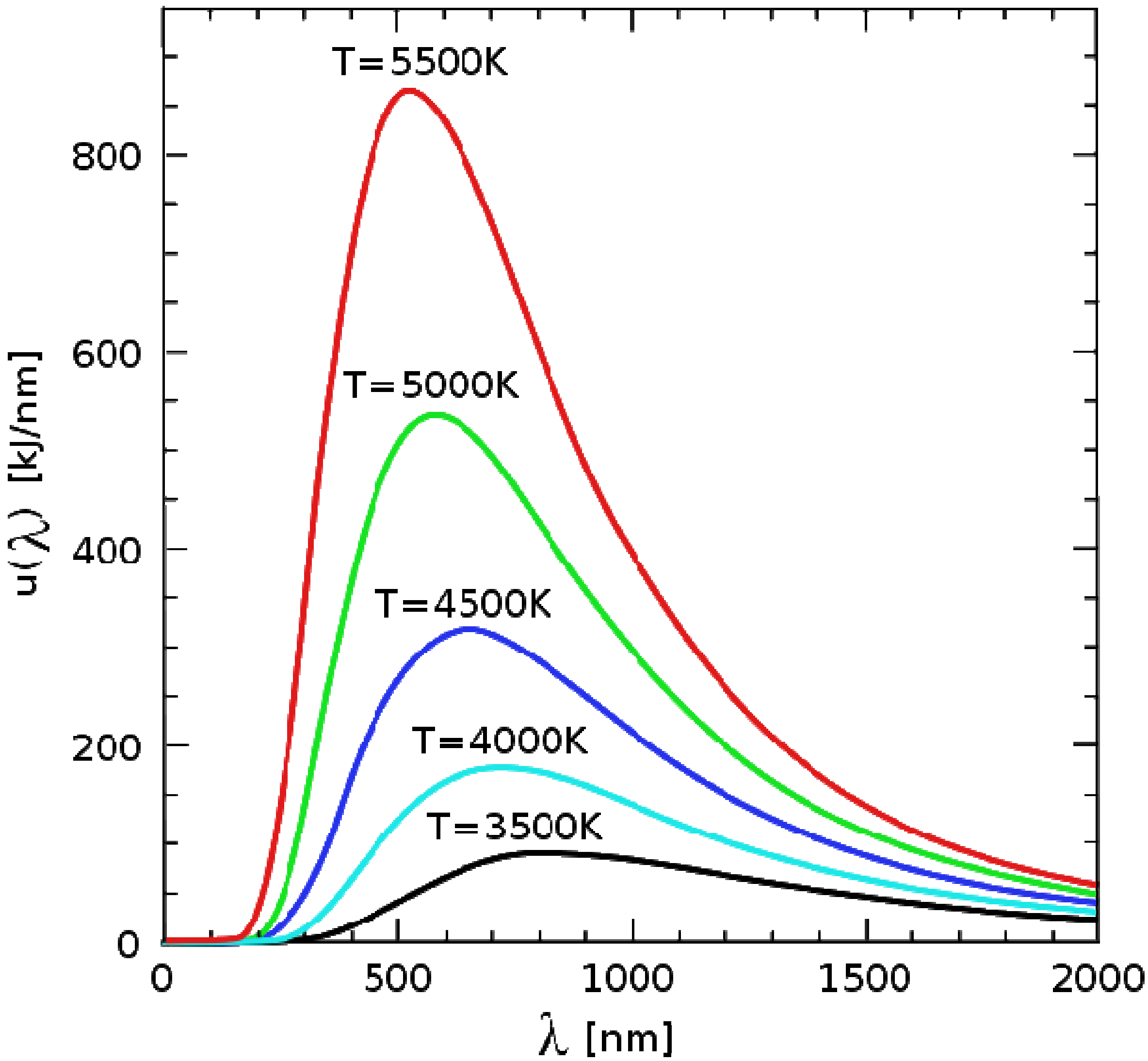


Figure 2. The distribution law for different T temperatures

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 $\boldsymbol{E = hv}$ and $\boldsymbol{E = mc^2}$, $\boldsymbol{m = hv/c^2}$ 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 $\boldsymbol{m_o}$ 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]

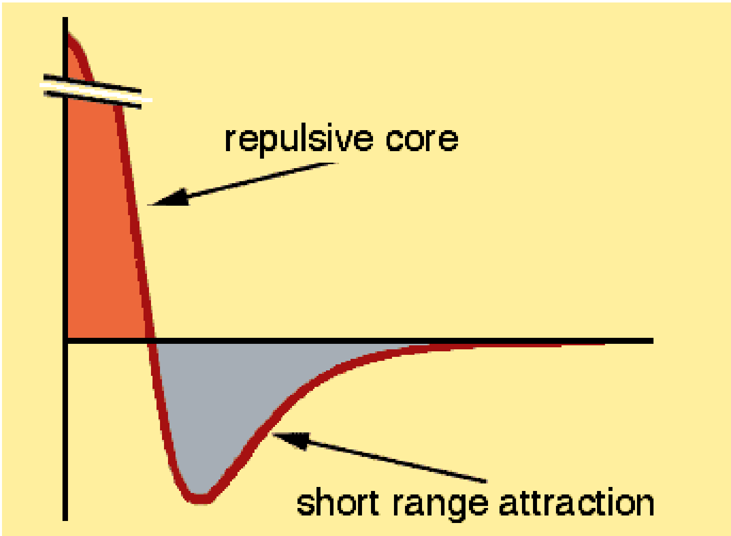
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a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

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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