Proton Quantum Tunneling

A discovery by a research team led by Northeastern's Paul Champion upends the understanding held for centuries of protons' behavior. The researchers—using an ultrafast pulsed laser system designed at Northeastern—have revealed that protons actually tunnel through thermodynamic barriers rather than travel over them. [12]

Scientists have discovered an anomaly in the properties of ice at very cold temperatures near 20 K, which they believe can be explained by the quantum tunneling of multiple protons simultaneously. The finding is a rare instance of quantum phenomena emerging on the macroscopic scale, and is even more unusual because it is only the second time—the first being superconductivity—that macroscopic quantum phenomena have been observed in a system that is based on fermions, which include protons, electrons, and all other matter particles. Other systems exhibiting macroscopic quantum phenomena have been based on photons, a type of boson, which mediate the forces between matter. [11]

Neutron scattering and computational modeling have revealed unique and unexpected behavior of water molecules under extreme confinement that is unmatched by any known gas, liquid or solid states. [10]

An international team of scientists studying ultrafast physics have solved a mystery of quantum mechanics, and found that quantum tunneling is an instantaneous process. The new theory could lead to faster and smaller electronic components, for which quantum tunneling is a significant factor. It will also lead to a better understanding of diverse areas such as electron microscopy, nuclear fusion and DNA mutations. [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!

Research sheds new light on proton behavior, draws praise from science community

Consider: You've always thought that the only way to travel from northern New Jersey to New York City was over the Hudson River via the George Washington Bridge. Then one day there's a news flash: The Lincoln Tunnel through the Hudson is actually much more efficient.

Northeastern professor Paul Champion and his colleagues have made a comparable discovery deep in the subatomic world of protons, the positively-charged particles found in the nucleus of every atom.

The paper was published Wednesday in the journal Nature Chemistry. Science magazine, struck by the results, highlighted it in its "Editor's Choice" column upon its publication online.

Protons play a major role in many biochemical systems critical to sustaining life, including photosynthesis and cellular respiration—the process by which cells release the energy stored in the chemical bonds of food molecules.

Classical physics posits that protons travel over thermodynamic barriers—that is, they hopscotch from one molecular compound to another within a system, sparking those biochemical reactions only when the temperature is high enough to kick them over the barrier.

Now Champion's team—using an ultrafast pulsed laser system designed at Northeastern—has revealed that protons can actually tunnel through those barriers, even at room temperature, sparking the reactions at a much faster rate than would be possible if they waited to be thermally kicked over the barrier.

The discovery upends the understanding held for centuries of protons' behavior as well as of the compounds involved in their transport. The next step is for researchers to mimic the behavior in the lab and then use it to develop new technologies. For example, tunneling could help transport protons across a membrane and lead to new types of batteries. In fact, certain types of biologically inspired batteries are already in the pipeline.

These environmentally clean rechargeable batteries are modeled after mitochondria, the energy factories of animal and plant cells. Just as mitochondria convert glucose, a simple sugar, into adenosine triphosphate at room temperature to power living cells, bio-batteries, when perfected, could convert the energy stored in glucose to power devices from laptops to cars.

"Biology can serve as an inspiration for the materials that researchers are trying to create," says Champion, chair of the Department of Physics. "Mitochondria are nature's own highly evolved battery system, and the currency of that battery system is protons. We found that protons tunnel incredibly fast at room temperature to move from one point to another. Indeed, that is their dominant mode of transport. It was a very, very surprising result."

Making a quantum leap

The team's novel understanding of how a proton operates underlies the tunneling capability: Rather than functioning as simply a particle, hopping over Point A to reach Point B, according to classical physics, the proton also functions as a wave, puncturing Point A to reach Point B, in line with quantum physics.

"At first we weren't sure what we were seeing," says Champion. "And then we finally realized the protons were tunneling at room temperature. The process was remarkably fast—so much faster than over-the-barrier classical transport. We were shocked."

For their experiment, the researchers turned to a protein called green fluorescent protein, or GFP, as a model system. GFP, first seen in the jellyfish Aequorea victoria, is commonly used as a marker in biomedical research because it emits a green glow. By inserting DNA from GFP into other proteins, researchers can follow GFP's colorful glow to track processes from nerve cell growth to cancer progression.

"The elements comprising GFP are well known," says Bridget Salna, the paper's first author and a doctoral student in physics. "The protons move internally a short distance in one direction and then they move back, among just four elements." They are: three compounds—a glutamic acid, a serine, and a water—and the chromophore, which determines the green color. The proton's journey, says Salna, is what sets off the green glow.

The researchers used light from their custom-designed lasers to trigger the proton-transport process, expectantly watching the particles' travels over broad time and temperature scales.

"By narrowing down the duration of the pulse we could actually see and track the molecular dynamics over the entire cycle," says Salna, PhD'17. "It was fascinating."

Among those recognizing the breakthrough was Martin Karplus, winner of the 2013 Nobel Prize in Chemistry with Michael Levitt and Arieh Warshel. "It certainly makes clear the importance of 'deep tunneling' in proton transfer reaction at room temperature," Karplus wrote in an email to Champion. "Congratulations!" [12]

Macroscopic quantum phenomena discovered in ice

Scientists have discovered an anomaly in the properties of ice at very cold temperatures near 20 K, which they believe can be explained by the quantum tunneling of multiple protons simultaneously. The finding is a rare instance of quantum phenomena emerging on the macroscopic scale, and is even more unusual because it is only the second time—the first being superconductivity—that macroscopic quantum phenomena have been observed in a system that is based on fermions, which include protons, electrons, and all other matter particles. Other systems exhibiting macroscopic quantum phenomena have been based on photons, a type of boson, which mediate the forces between matter.

The scientists, Fei Yen at the Chinese Academy of Sciences and Tian Gao at Shanghai University of Electric Power, have published a paper on the anomaly in ice in a recent issue of The Journal of Physical Chemistry Letters.

Ice rules

As the scientists explain, when water freezes, the oxygen atoms in the ice become ordered into a puckered hexagonal-like lattice. The hydrogen atoms, on the other hand, remain quite disordered.

This freezing process is governed by the two "ice rules," which state that only one hydrogen atom can reside between two oxygen atoms, while each oxygen atom can be bonded to four hydrogen atoms by bonds of two different lengths.

Because of the two different bond lengths, between each pair of oxygen atoms, there are two sites available for a single hydrogen atom (which has lost its electron and simply becomes a proton). At high enough temperatures (above 136 K), the protons have enough energy to move between the two sites. However, when the temperature falls below 136 K, the protons no longer have enough energy to move between sites and randomly "freeze" in one of the sites.

Tunneling protons

Now in the new study, the scientists have found that the protons actually can move between these two sites even at very cold temperatures of less than 20 K. The protons cannot move by classical means (as they don't have enough energy), but by quantum tunneling through the classical energy barrier.

Although quantum tunneling occurs due to the wave-like nature of particles at the quantum scale, and is not possible at the macroscopic level, here the scientists demonstrate that the total combined effects of quantum tunneling can be witnessed and measured at the macroscopic level. The macroscopic evidence for the quantum phenomena comes from measuring the dielectric properties of ice. As a dielectric material, ice is an electrical insulator, but in the presence of an electric field the molecules become polarized so that they align themselves with the electric field.

To investigate the dielectric properties of ice, the scientists made measurements on a pair of platinum plates inserted into ice inside a Teflon container, all of which was frozen in a cryostat. The researchers discovered the existence of a minimum in the imaginary part of the dielectric constant of ice at 20 K but no change in the real part. As the scientists explain, the physical meaning of this anomaly can be interpreted as an increase in the movement of charges—in other words, protons moving back and forth between sites. They also found that no anomaly occurs in heavy ice (i.e., deuterium, which contains a proton and a neutron), indicating that the discovery also exhibits an isotope effect.

How do the protons do it?

To better understand what may be happening at the atomic level, the researchers again turned to the ice rules. According to these rules, single protons cannot move between sites one at a time, as this interferes with the highly ordered crystal structure of ice. However, the ice rules remain preserved if all six protons within a hexagonal ring move at the same time, which suggests that the six protons engage in correlated tunneling.

But correlated tunneling poses another problem. According to the laws of quantum mechanics, for several protons to tunnel simultaneously, they must all have the same wave function and occupy the same ground state. However, this arrangement directly violates the Pauli exclusion principle, which expressly states that no two identical fermions can simultaneously occupy the same quantum state.

To overcome this problem, the scientists conjecture that the protons tunnel in pairs because a proton pair can act as a boson, which is allowed to collapse into its ground state because it is not subject to the exclusion principle. This proposal is similar to the underlying mechanism of superconductivity, which is caused by paired electrons forming a "Cooper pair" that also acts as a boson and condenses into its ground state. In both situations, pairing allows for multiple fermions to move together simultaneously, giving rise to macroscopic quantum phenomena that wouldn't otherwise be allowed.

Going forward

Observing macroscopic quantum phenomena is not only of fundamental interest, but the researchers predict that it may be very useful one day, as well.

"With new phenomena usually comes new applications, and there is no exception in the realm of macroscopic quantum phenomena; see, for instance, what has been accomplished with superconductivity and lasers," Yen told Phys.org. "As for correlated proton tunneling, perhaps a higher accuracy can be obtained on some of the fundamental constants, such as the case of the quantum hall effect, where the von Klitzing and fine structure constants have been determined to higher precision."

In the future, the scientists plan to look for the same quantum phenomenon in related systems.

"We believe that correlated proton tunneling on the macroscopic scale is not strictly limited to ice and should also occur in other hydrogen-based compounds provided the temperature is low enough," Yen said. "Currently, we are still investigating water ice, though at higher pressures, where the ices crystallize in tetragonal, monoclinic or interpenetrating cubic lattices to see if the same phenomenon is also present." [11]

New state of water molecule discovered

Neutron scattering and computational modeling have revealed unique and unexpected behavior of water molecules under extreme confinement that is unmatched by any known gas, liquid or solid states.

In a paper published in Physical Review Letters, researchers at the Department of Energy's Oak Ridge National Laboratory describe a new tunneling state of water molecules confined in hexagonal ultra-small channels - 5 angstrom across - of the mineral beryl. An angstrom is 1/10-billionth of a meter, and individual atoms are typically about 1 angstrom in diameter.

The discovery, made possible with experiments at ORNL's Spallation Neutron Source and the Rutherford Appleton Laboratory in the United Kingdom, demonstrates features of water under ultra confinement in rocks, soil and cell walls, which scientists predict will be of interest across many disciplines.

"At low temperatures, this tunneling water exhibits quantum motion through the separating potential walls, which is forbidden in the classical world," said lead author Alexander Kolesnikov of ORNL's Chemical and Engineering Materials Division. "This means that the oxygen and hydrogen atoms of the water molecule are 'delocalized' and therefore simultaneously present in all six symmetrically equivalent positions in the channel at the same time. It's one of those phenomena that only occur in quantum mechanics and has no parallel in our everyday experience."

The existence of the tunneling state of water shown in ORNL's study should help scientists better describe the thermodynamic properties and behavior of water in highly confined environments such as water diffusion and transport in the channels of cell membranes, in carbon nanotubes and along grain boundaries and at mineral interfaces in a host of geological environments.

ORNL co-author Lawrence Anovitz noted that the discovery is apt to spark discussions among materials, biological, geological and computational scientists as they attempt to explain the mechanism behind this phenomenon and understand how it applies to their materials.

"This discovery represents a new fundamental understanding of the behavior of water and the way water utilizes energy," Anovitz said. "It's also interesting to think that those water molecules in your aquamarine or emerald ring - blue and green varieties of beryl - are undergoing the same quantum tunneling we've seen in our experiments."

While previous studies have observed tunneling of atomic hydrogen in other systems, the ORNL discovery that water exhibits such tunneling behavior is unprecedented. The neutron scattering and computational chemistry experiments showed that, in the tunneling state, the water molecules are delocalized around a ring so the water molecule assumes an unusual double top-like shape.

"The average kinetic energy of the water protons directly obtained from the neutron experiment is a measure of their motion at almost absolute zero temperature and is about 30 percent less than it is in bulk liquid or solid water," Kolesnikov said. "This is in complete disagreement with accepted models based on the energies of its vibrational modes."

First principle simulations made by Narayani Choudhury of Lake Washington Institute of Technology and University of Washington-Bothell showed that the tunneling behavior is coupled to the vibrational dynamics of the beryl structure. [10]

Physicists solve quantum tunneling mystery

At very small scales quantum physics shows that particles such as electrons have wave-like properties – their exact position is not well defined. This means they can occasionally sneak through apparently impenetrable barriers, a phenomenon called quantum tunneling.

Quantum tunneling plays a role in a number of phenomena, such as nuclear fusion in the sun, scanning tunneling microscopy, and flash memory for computers.

However, the leakage of particles also limits the miniaturisation of electronic components.

Professor Kheifets and Dr. Igor Ivanov, from the ANU Research School of Physics and Engineering, are members of a team which studied ultrafast experiments at the attosecond scale (10-18 seconds), a field that has developed in the last 15 years.

Until their work, a number of attosecond phenomena could not be adequately explained, such as the time delay when a photon ionised an atom.

“At that timescale the time an electron takes to quantum tunnel out of an atom was thought to be significant. But the mathematics says the time during tunneling is imaginary – a complex number – which we realised meant it must be an instantaneous process,” said Professor Kheifets.

"A very interesting paradox arises, because electron velocity during tunneling may become greater than the speed of light. However, this does not contradict the special theory of relativity, as the tunneling velocity is also imaginary" said Dr Ivanov, who recently took up a position at the Center for Relativistic Laser Science in Korea.

The team's calculations, which were made using the Raijin supercomputer, revealed that the delay in photoionisation originates not from quantum tunneling but from the electric field of the nucleus attracting the escaping electron.

The results give an accurate calibration for future attosecond-scale research, said Professor Kheifets.

"It's a good reference point for future experiments, such as studying proteins unfolding, or speeding up electrons in microchips," he said. [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) $M_p = n^2 M_e$

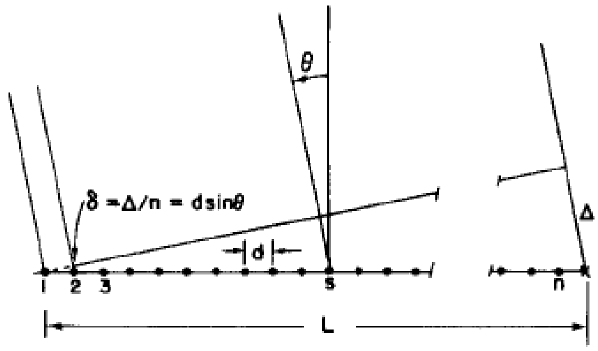


Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

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:

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

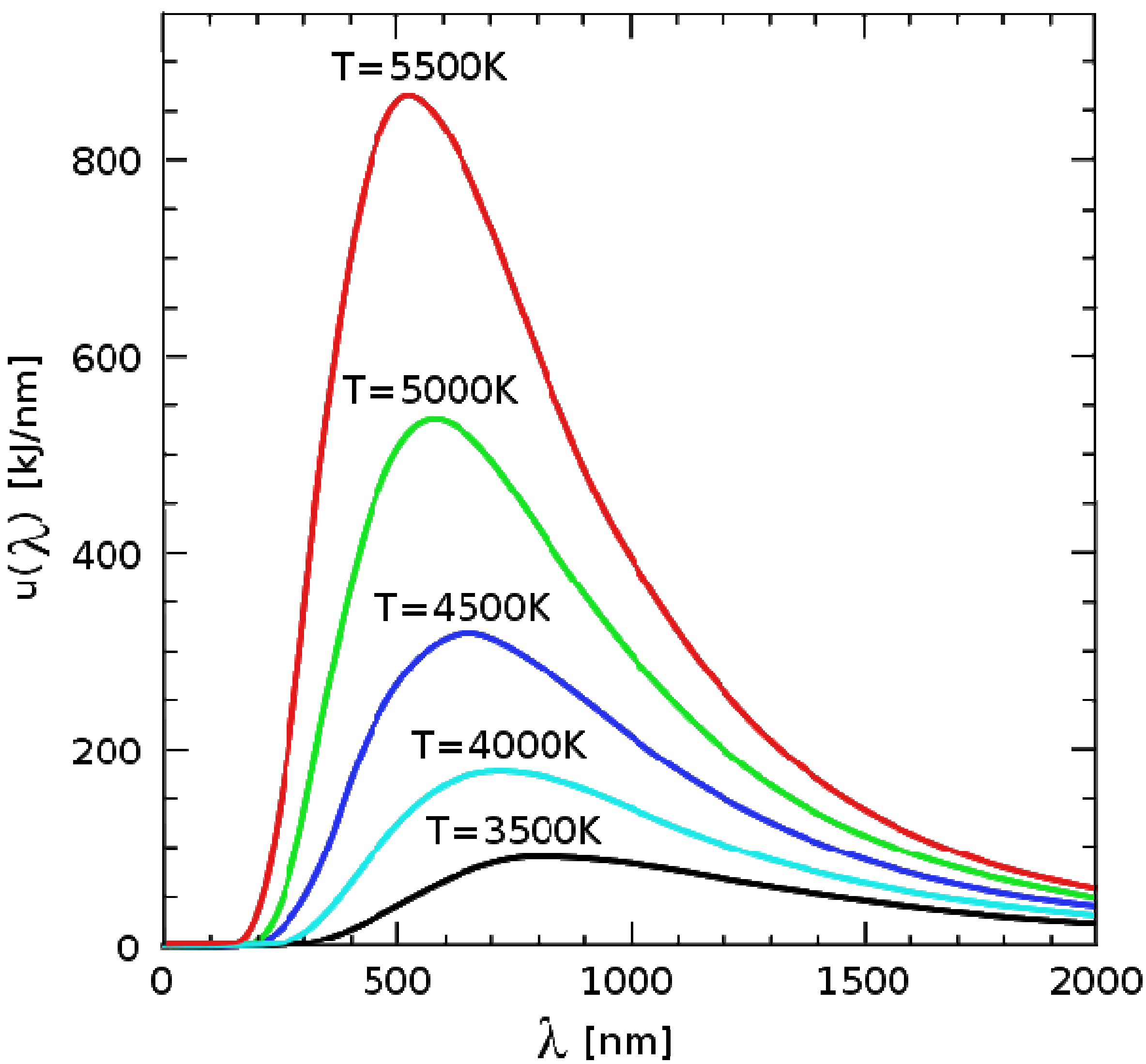


Figure 2. The distribution law for different T temperatures

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

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

The structure of the proton

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

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

The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking. This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

The Strong Interaction - QCD

Confinement and Asymptotic Freedom

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

Lattice QCD

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

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

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

QCD

QCD enjoys two peculiar properties:

- **Confinement**, which means that the force between quarks does not diminish as they are separated. Because of this, it would take an infinite amount of energy to separate two quarks; they are forever bound into hadrons such as the proton and the neutron. Although analytically unproven, confinement is widely believed to be true because it explains the consistent failure of free quark searches, and it is easy to demonstrate in lattice QCD.

- **Asymptotic freedom**, which means that in very high-energy reactions, quarks and gluons interact very weakly. This prediction of QCD was first discovered in the early 1970s by David Politzer and by Frank Wilczek and David Gross. For this work they were awarded the 2004 Nobel Prize in Physics.

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

Color Confinement

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

Electromagnetic inertia and mass

Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

The frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv / c^2$ that is the m depends only on the v frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other. [2]

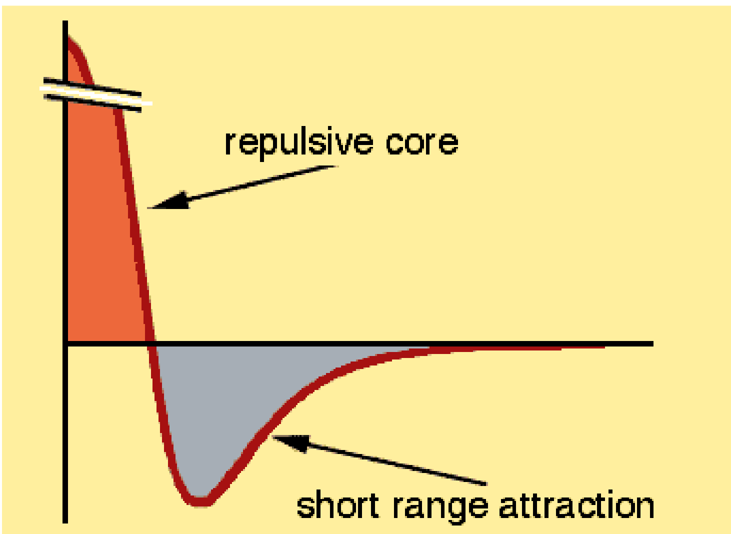
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The potential of the diffraction pattern

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

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

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



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

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

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

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

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

Conclusions

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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