How Does Strong Interaction Create

Yin Rui , Yin Ming, Wang Yang   BeiHang University

Abstract

Our experiment shows that the electrons at fixed place can exert both repulsion and attraction to the negative charges in the same time but at two sides of a boundary called critical radius, where the linear velocity of the electrons' precession is equal to light speed. This is an uncovered natural law called Critical Cylindrical Effect (CCE) deduced from rotational relativity and proved by the experiments made in our lab. Ten screenshots of the experimental video are given in this paper. This experimental result denotes that both Coulomb's law and the spin theory of quantum mechanics are incomplete. As an application of CCE, the strong interaction between two protons in nucleus is introduced. It just is the electromagnetic interaction suffered from CCEs of spin and precession.

Lorentz Transformation for rotational Frames

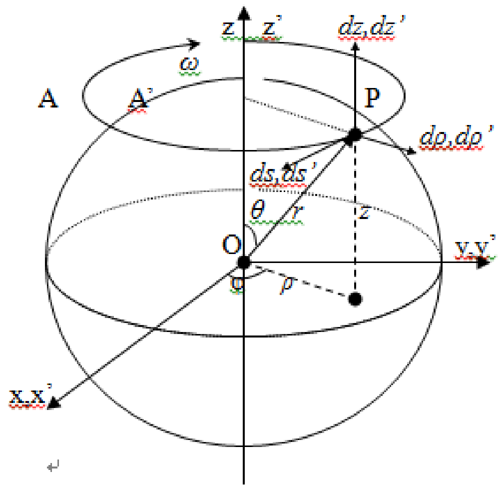


Fig.1.Coordinate systems and local frame of P

Consider two frames A and A' are relatively rotating about a fixed axis z (z') with constant angular velocity ω. There is a radial distance ρ_c where the linear velocity $\rho_c\omega$ equals the light speed c, and call $\rho_c=c/\omega$ the critical radius. The set of all points separated from axis z by ρ_c forms a cylinder, called critical cylinder. It is well known that substituting the local reference frames of event point P for inertial frames [1], i.e. substituting differentials of arc length, radial distance, axial distances and time（$ds,d\rho,dz,dt$）for（x,y,z,t）and $\rho\omega$ for v into the Lorentz transformation of inertial frames (1), the Lorentz transformation for rotational frames can be derived for the area of Inside Critical Cylinder (ICC) as shown in (2):

$$\begin{cases} x=\gamma(x'+vt') \\ y=y' \\ z=z' \\ t=\gamma(t'+\dfrac{v}{c^2}x') \end{cases} \quad (1) \qquad \begin{cases} ds=\gamma(ds'+\rho\omega dt') \\ d\rho=d\rho' \\ dz=dz' \\ dt=\gamma(dt'+\dfrac{\rho\omega}{c^2}ds') \end{cases} \quad (2) \quad \text{where: } \gamma=\begin{cases} (1-v^2/c^2)^{-1/2} \\ (1-\rho^2\omega^2/c^2)^{-1/2} \\ (1-\rho^2/\rho_c^2)^{-1/2} \end{cases} \quad (3)$$

In the last section of this paper, it is proved that for OCC the linear velocity v is no longer $\rho\omega$ *or* $c\rho/\rho_c$ but $c^2/(\rho\omega)$ or $c\rho_c/\rho$, which is always less than light speed c. And the Lorentz factor for OCC is:

$$\gamma'=-[1-v^2/c^2]^{-1/2}=-[1-c^2/(\rho^2\omega^2)]^{-1/2}=-(1-\rho_c^2/\rho^2)^{-1/2} \qquad (4)$$

Thus, let:

$$v(\rho)=\begin{cases} c\rho/\rho_c & \rho<\rho_c \\ c\rho_c/\rho & \rho>\rho_c \end{cases} \quad (5) \qquad \gamma(\rho)=\begin{cases} (1-\rho^2/\rho_c^2)^{-1/2} & \rho<\rho_c \\ -(1-\rho_c^2/\rho^2)^{-1/2} & \rho>\rho_c \end{cases} \quad (6)$$

The Lorentz transformations for both ICC and OCC can be uniformly denoted as follows:

Transformation inverse

$$\begin{cases} ds'=\gamma(\rho)(ds-v(\rho)dt) \\ d\rho'=d\rho \\ dz'=dz \\ dt'=\gamma(\rho)(dt-\dfrac{v(\rho)}{c^2}ds) \end{cases} \quad (7) \qquad \begin{cases} ds=\gamma(\rho)(ds'+v(\rho)dt') \\ d\rho=d\rho' \\ dz=dz' \\ dt=\gamma(\rho)(dt'+\dfrac{v(\rho)}{c^2}ds') \end{cases} \quad (8)$$

The forms are similar as the Lorentz transformations in special relativity, so that the transformations of other physical quantities can be got in the same way as those in special relativity, except the tangential force transformation. Following are the inverse transformations of mass (m), energy (w) momentum (p), radial force F_ρ, axial force F_z and their composition F_R, (see references [2],[3]):

$$m=\gamma(\rho)m'[1+u_s'v(\rho)/c^2] \qquad (9)$$

$$w=\gamma(\rho)(w'+v(\rho)p_s'); \quad p_s=\gamma(\rho)(p_s'+v(\rho)w'/c^2) \qquad (10)$$

$$F_{\rho/z/R} = \frac{F'_{\rho/z/R}}{\gamma(\rho)[1+u'_s v(\rho)/c^2]} = \gamma(\rho)F'_{\rho/z/R}[1-u_s v(\rho)/c^2] \tag{11}$$

By means of these transformations, some undiscovered natural law can be revealed. The most important one is that lots of physical quantities of a rotating body in lab frame (energy, momentum, mass, force, etc) will change mathematical sign as the radial distance is changed from ICC to OCC, because the Lorentz factor $\gamma(\rho)$ takes different mathematical sign. We call this just discovered natural law as Critical Cylindrical Effect. Now let us give its detail by means of discussing electrical force.

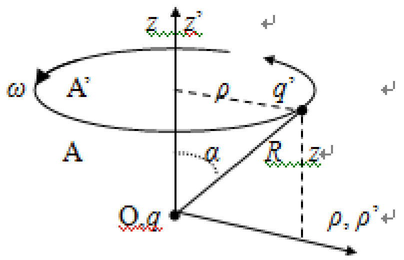


Fig. 2 The geometry for finding field of q

Critical Cylindrical Effect (CCE)

Suppose charged particle q in lab is located at the origin (O) without shift but spinning with angular velocity ω about z axis (see Fig. 2), the test charge q' is separated from it by the distance of $R=(\rho^2+z^2)^{1/2}$. Take the spin frame of q as A' and lab frame as A, then q is truly at rest in frame A' (neither shift nor rotate). The force F_R', exerted on q' by q in frame A' is the true electrostatic force（Actually it isn't the Coulomb's force, because it attracts the charge with the same sign, although it is in inverse square law, which is proved in references [2],[3]). In terms of (11), in lab frame A this force will be transformed as follows:

$$F_R = \frac{F'_R}{\gamma(\rho)[1+u'_s v(\rho)/c^2]} = \gamma(\rho)F'_R[1-u_s v(\rho)/c^2] \tag{12}$$

Where: u_s' and u_s are the tangential velocity of q' in spinning frame A' or in lab frame A respectively.

Obviously, the force in lab frame F_R is depending on the moving state (u_s) of test charge q'. If test charge q' is without shift in lab frame, i.e. u_s=0, then this force is: $F_R = \gamma(\rho)F'_R$, i.e.:

$$\frac{F_R}{F'_R} = \gamma(\rho) = \begin{cases} (1-\rho^2/\rho_c^2)^{-1/2} & \rho < \rho_c \\ -(1-\rho_c^2/\rho^2)^{-1/2} & \rho > \rho_c \end{cases} \tag{13}$$

We call it the first kind of Critical Cylindrical Effect (CCE). It means the force in lab will become very strong if $\rho \to \rho_c$, and will change direction when the location of test charge is changed from ICC to OCC, as shown in Fig.3. For example, if ρ=0.999ρ_c, F_R=22.4F_R'; and if ρ=1.001ρ_c, F_R= -22.4F_R'. This is the source of so called strong interaction between protons in nucleus. As we know the strong interaction is present at $\rho \approx 10^{-13}$cm, then the critical radius of proton's spin is in the level of $\rho_c=10^{-13}$cm. We know as $\rho>\rho_c=10^{-13}$cm the proton repel to positive charge, so they must attract to positive charge as $\rho<\rho_c$, and so is the true electrostatic force F_R' (in spinning frame A'). In other words, the true electrostatic force is attracting to the same sign charge, and it only exists in the spinning frame A'.

If q' is synchronously rotating with the spin of q, i.e. $u_s=v(\rho)$, then equation (12) will become to:

$$F_R = F_R^{'} / \gamma(\rho) \text{,i.e.,} F_R / F_R^{'} = 1/\gamma(\rho) \tag{14}$$

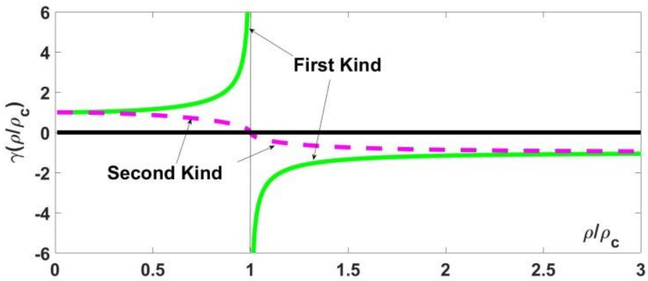


Fig3. Critical Sylindrical Effects

We call 1/γ(ρ) the second kind of CCE. It means the force becomes quietly weak if $\rho \to \rho_c$, and will gently change direction if the location of q' is changed from ICC to OCC. This is the source of so-called weak interaction.

In general, $0 \neq u_s \neq v(\rho)$, the force exerted on moving charge q' by spinning charge q can be denoted as two parts:

$$F_R = F_e + F_m = F_R^{'}\gamma(\rho) - F_R^{'}\gamma(\rho)u_s v(\rho)/c^2 \tag{15}$$

Where: $F_e = F_R^{'}\gamma(\rho)$ is the electrical force and $F_m = -F_R^{'}\gamma(\rho)u_s v(\rho)/c^2$ is the magnetic force.

And the electric field and magnetic field of spinning charge q in lab frame are as follows:

$$E_e = -q\gamma(\rho)/(4\pi\varepsilon_0 R^2),\quad B_s = q\gamma(\rho)v(\rho)/(4\pi\varepsilon_0 R^2 c^2) = q\gamma(\rho)v(\rho)\mu_0/(4\pi R^2) \tag{16}$$

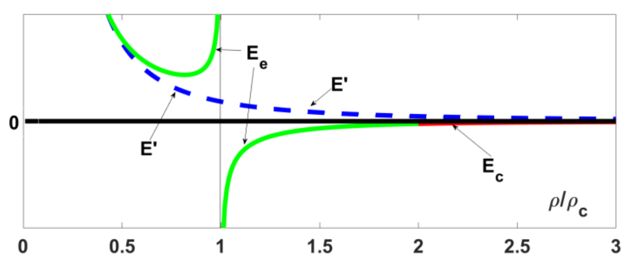


Fig.4 Electrostatic Field E', Electric Field E_e, Coulomb's Field E_c

Thus we know that in lab the no-shifting but spinning charged particle possesses both electric field E_e and magnetic field B_s. Coulomb's field (E_c) is neither the real electrostatic field (E') nor the complete electric field (E_e) of spinning charged particle, it only is the part of E_e at $\rho>>\rho_c$. The relationship between them is shown in Fig.4, where only E'(in spinning frame) is in the inverse square law with single sign. Undergoing CCE, the E' (in frame A') is transformed into E_e of lab frame A, which possesses different sign at the two sides of critical radius. And the Coulomb's field E_c is only the part of E_e at $\rho>>\rho_c$ as shown in Fig.4.

The experimental observation of CCE

The critical radius of spin is 10^{-16}cm for electron, and for proton it is 10^{-13}cm. They are too small to be observed directly by human eyes. However, we can create a rotation with critical radius in centimeters level via putting external magnetic field B to the spinning charged particle. We call this as rotation magnetic precession. It is well known that if the spin magnetic moment M of a spinning charged particle is inclined to external magnetic field B, the spinning particle will be precession with the frequency of $\omega_p= -2\pi\gamma B$ about the axis $\boldsymbol{\omega_P}$, which is parallel to B. Note that here γ is gyromagnetic ratio but not Lorentz factor. Suppose B is along z direction, the spinning charged particle q is located at the origin (O) without shifting but spinning with angular velocity ω_s about $\boldsymbol{\omega_s}$ axis, which is inclined to B by a, as shown in Fig.5. Take the lab frame as A, relative to A take the precession frame as A', then relative to A' take spinning frame as A", which is spinning about spin axis $\boldsymbol{\omega_s}$ with the angular velocity of $\omega_s{}'=\omega_s-\omega_p\approx\omega_s$ (as $\omega_s>>\omega_p$). Thus, in frame A" q is truly at rest, the force exerted on test charge q' by q is the true electrostatic force F_R". First, inverse transforming F_R" into frame A' by (11) we have:

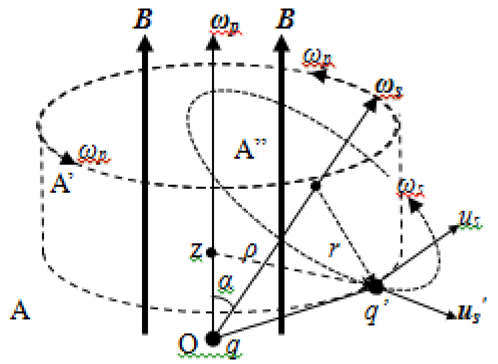


Fig. 5. The geometry for finding force exerted on q' by spinning charged particle q in external magnetic field B

$$F_R^{'} = F_R^{''}\gamma_s(r)[1-u_s^{'}v_s(r)/c^2] \tag{17}$$

Where r is the radial distance from spin axis to q', $u_s{}'$ is the tangential velocity of q' relative to spin of q in precession frame A'. Then inverse transforming F_R' into lab frame, we have:

$$F_R = F_R^{''}\gamma_s(r)\gamma_p(\rho)[1-u_s^{'}v_s(r)/c^2][1-u_s v_p(\rho)/c^2] \tag{18}$$

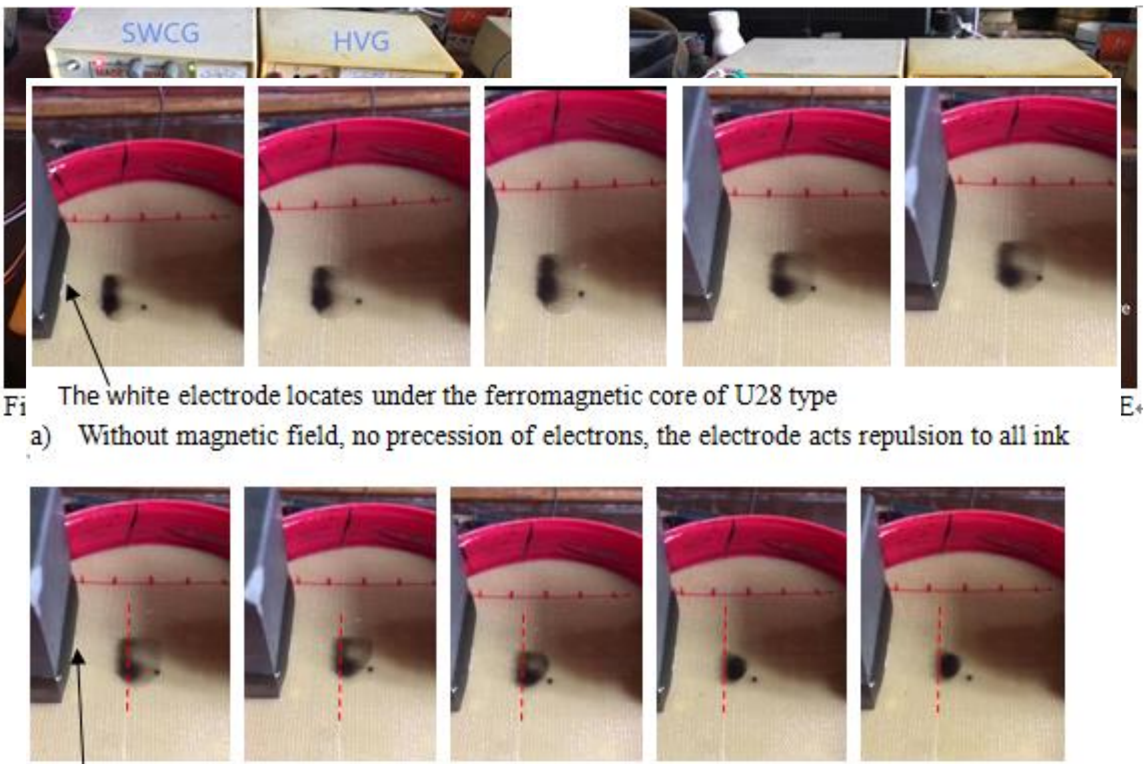
Where ρ is the radial distance from precession axis to q'; u_s is the tangential velocity of q' relative to the precession of q in lab frame A.

Since the critical radius of spin is far less than that of magnetic precession, we can think that $\gamma_s(r)$=-1 and $u_s'v_s(r)$<<c^2 at the place near the critical radius of precession, and the force F_R' is just the Coulomb's force F_c, then we have:

$$F_R = F_c\gamma_p(\rho)[1-u_s v(\rho)/c^2] \xrightarrow{u_s=0} = F_c\gamma_p(\rho) \tag{19}$$

For electron γ_e=2.6667MHz/Gs, so the critical radius of its precession is ρ_c=c/(2π$\gamma_e B$)=1.79/B (cm/KGs). For example, if B=1300Gs, then the critical radius of precession will be ρ_c=1.377cm. Thus, the CCE of its precession can be observed at the distance of centimeters. It means that if the radial distance is less than 1.377cm, the electron will act repulsion to negative charge, and if the radial distance is more than 1.377cm, the force will become attraction. Following experiment is just based on this principle.

The spiral electrode is connected with the negative terminal of D.C. High-Voltage Generator (HVG), and is sandwiched by two U-type ferromagnetic cores. The other two ends of the cores are inserted into the coils, which are excited by Square-Wave Current Generator (SWCG) as shown in Fig.(6) and (7). So, if the HVG is turned on, lots of free electrons will collect on the surface of electrode, and if the SWCG is also turned on, those electrons will precession. Taking the magnetic field passing through the electrode is 1300 Gs, the



a) Without magnetic field, no precession of electrons, the electrode acts repulsion to all ink

b) The magnetic precession of electrons makes the force acted to ink be both repulsion (at the left side of 1.377cm) and attraction (at the right side of 1.377cm)

Fig.8 The experimental observation of CCE critical radius of electrons' precession will be 1.377cm.

Take the black ink as the test charge (there is anion surfactant besides carbon and glue in it), which is injected in a plastic dish filled with water. As HVG (1500V) is only turned on, all of the ink suffered from repulsion acted by the electrons on electrode as shown in Fig.8. a), which are five screenshots taken from the experimental video sequentially. On the five screenshots the ink is moved to righter and righter, means the force exerted on ink is repulsion only. However, after the SWCG is turned on, the ink near the electrode is suffered from repulsion again, but the distant ink suffered from attraction, which makes the ink go to left! The boundary line is separated from electrode about 1.377cm as shown in Fig.8 b), which is sequentially taken in the same experimental video. This experimental result denotes that there surely is CCE for every rotation, and the electrical force in lab will really change direction if the test charge is changed from ICC to OCC. This natural law has not been discovered till now. We give it both theoretically and experimentally. Thus, the Coulomb's law is proved to be incomplete, the CCE must be taken into account in the research of particle world.

On the other hand, this experiment proves the spin of electron is real rotation about axis, since only the rotating body can create precession, as it suffers from external moment. This clearly means the spin theory of quantum mechanics is based on a wrong foundation. Deny the spin of charged particles is rotation, unknown CCE of rotating, quantum mechanics can't uncover the essence of particle world. In fact, even if the quantum property itself is coming from the CCE, we will give the details in another paper. Now let's uncover the essence of strong interaction first and then prove the spin of basic particle is rotation about axis.

The Creation of Strong Interaction

Now we calculate the force between two protons in two protons system. Every proton possesses spin and spin magnetic field, that makes the other proton precession and create precession magnetic field, which make the origin proton precession and create precession magnetic field. So there are two rotations, spin and precession for every proton, and the precession is caused by spin magnetic field and precession magnetic field of the other proton. As shown in Fig.5. if q and q' are two protons, it just is a two protons system. The only difference is that the magnetic field is not external but come from the spin and precession of the other proton, so we call this precession as inner magnetic precession. In terms of equation (18), we have:

$$F_R = F_R^{''}\gamma_s(r)\gamma_p(\rho)[1-u_s^{'}v_s(r)/c^2][1-u_s v_p(\rho)/c^2]$$

$$= F_R^{''}\gamma_s(r)\gamma_p(\rho)[1-u_s^{'}v_s(r)/c^2 - u_s v_p(\rho)/c^2 + u_s^{'}u_s v_s(r)v_p(\rho)/c^4] \quad (20)$$

This equation gives the expressions of electrical field E_e, spin magnetic field B_s, precession magnetic field B_p and spin-precession magnetic field B_{s-p} of every proton as follows:

$$E_e = kq\gamma_s(r)\gamma_p(\rho)/R^2 = q\gamma_s(r)\gamma_p(\rho)/(4\pi\varepsilon_0 R^2) \quad (21)$$

$$B_s = q\gamma_s(r)\gamma_p(\rho)/(4\pi\varepsilon_0 R^2)\times v_s(r)/c^2 = q\gamma_s(r)\gamma_p(\rho)v_s(r)\mu_0/(4\pi R^2) \quad (22)$$

$$B_p = q\gamma_s(r)\gamma_p(\rho)v_p(\rho)\mu_0/(4\pi R^2) \quad (23)$$

$$B_{s-p} = -q\gamma_s(r)\gamma_p(\rho)[v_s(r)/c][v_p(\rho)/c]\mu_0/(4\pi R^2) \quad (24)$$

Since $v_s(r)\le c$, $v_p(\rho)\le c$, $[v_s(r)/c][v_p(\rho)/c] << [v_s(r)+v_p(\rho)]$, B_{s-p} is far less than B_s and B_p. We neglect B_{s-p}. Knowing the inner magnetic fields, the angular velocity of inner magnetic precession can be got as follows:

$$\omega_p = 2\pi\gamma(B_p + B_s) = 2\pi\gamma q\gamma_s(r)\gamma_p(\rho)[v_p(\rho)+v_s(r)]\mu_0/(4\pi R^2) \quad (25)$$

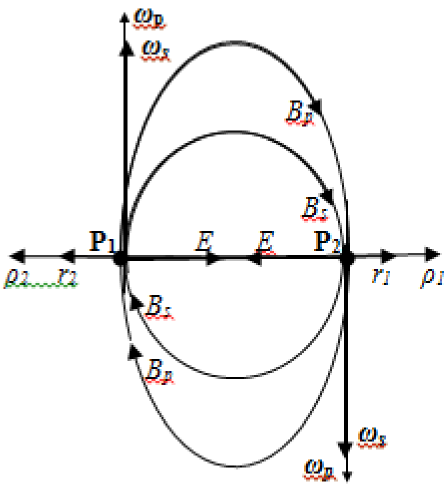


Fig.9. The fields in two protons system

Where γ=4.257KHz/Gs is the gyromagnetic ratio of proton.

At the stable state the spin axis and precession axis of a proton must be almost coincide to each other because there is spin-spin relaxation. And the two axes of the two protons must be anti-parallel to each other, as shown in Fig.9. Otherwise the magnetic field of the other proton will be canceled by the magnetic field of itself (only at the place that proton occupies), the inner magnetic precession will disappear. (This is the relativistic explanation of Pauli principle). In other worlds, the radial directions of spin (r) and precession (ρ) are coincided too. Our calculation is based on this stable situation.

The critical radius of proton's spin is an intrinsic parameter which is invariant. Unfortunately we don't know its accuracy value. As an example we suppose it is r_c=1×10^{-13}cm to uncover the mechanism of creating strong interaction. (The algorithm is just the same if r_c is some other value). The critical radius of precession ρ_c must be less than r_c (otherwise the state can't be stable). For getting attraction between P_1 and P_2, their interval R must be more than r_c (and ρ_c), we take it to be $R=r_c$+b, where b is the size of charge ball of proton, and is in the level of 10^{-16}cm (see another paper). Thus we have: r_c=1×10^{-13}cm, R=1.001×10^{-13}cm. Now let us find the suitable ρ_c, which can keep the system stable. We use iterative algorithm to approximate it. Without losing generality we can take any value less than r_c as the beginning value, say ρ_c=0.98×10^{-13}cm. Then we have:

$$\gamma_s(R) = -[1-(1/1.001)^2]^{-1/2} = -22.3775, \qquad v_s(R) = (1/1.001)\times 3\times 10^8 = 2.9970\times 10^8 m/s$$

$$\gamma_p(R) = -[1-(0.98/1.001)^2]^{-1/2} = -4.9077, \qquad v_p(R) = (0.98/1.001)\times 3\times 10^8 = 2.9370\times 10^8$$

Note that $2\pi\gamma$=26.7475×10^3 r/(sGs), q=1.602×10^{-19}C, μ_0=4π×10^{-7}H/m, we have:

$$\omega_p = [26.7475\times 1.602\times 22.3775\times 4.9077\times 5.934/(1.001)^2]\times 10^{19} = 2.7869\times 10^{23} r/s$$

Corresponding ρ_c=c/ω_p=1.0765×10^{-13}cm, which is more than the initial evaluation of ρ_c=0.98×10^{-13}cm. This means that we have to take bigger ρ_c to do next iteration, say take ρ_c=0.985×10^{-13}cm. In this case we have:

$\gamma_s(R) = -22.3775, v_s(R) = 2.9970\times 10^8 m/s$, $\gamma_p(R) = -5.6154, v_p(R) = 2.9520\times 10^8$, and get ω_p=3.1957×10^{23} r/s, ρ_c=0.9387×10^{-13}cm, which is less than 0.985×10^{-13}cm. It means the stable value must be less than ρ_c=0.985×10^{-13}cm. Then take ρ_c=0.983×10^{-13}cm for the third iteration. We can make iterations as follows:

take ρ_c=0.983×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_p(R)$=-5.2970, ω_p=3.0023×10^{23} r/s, ρ_c=0.9992×10^{-13}cm, need ↑

take ρ_c=0.9836×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_p(R)$=-5.3867, ω_p=3.0583×10^{23} r/s, ρ_c=0.9809×10^{-13}cm, ↓

take ρ_c=0.9834×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_p(R)$=-5.3563, ω_p=3.0468×10^{23} r/s, ρ_c=0.9846×10^{-13}cm, ↑

take ρ_c=0.9835×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_p(R)$=-5.3714, ω_p=3.0555×10^{23} r/s, ρ_c=0.9818×10^{-13}cm, ↓

take ρ_c=0.98343×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_p(R)$=-5.3608, ω_p=3.0494×10^{23} r/s, ρ_c=0.98379×10^{-13}cm, ↑

take ρ_c=0.98345×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_\rho(R)$=-5.3638, ω_p=3.05119×10^{23} r/s, ρ_c=0.98322×10^{-13}cm, ↓

take ρ_c=0.98344×10^{-13}cm, get $\gamma_s(R)$=-22.3775, $\gamma_\rho(R)$=-5.3623, ω_p=3.05036×10^{23} r/s, ρ_c=0.98349×10^{-13}cm, ↑

Thus, we get the stable state ρ_c=0.98344 ••• ×10^{-13}cm , r_c=1×10^{-13}cm, R=1.001×10^{-13}cm. And in this case $\gamma_s(R)\ \gamma_\rho(R)$= 119.9953≈120. The force between the two protons is:

$$F_R = kq^2\gamma_s(R)\gamma_p(R)/R^2 = q^2\gamma_s(R)\gamma_p(R)/(4\pi\varepsilon_0 R^2) = 120q^2/(4\pi\varepsilon_0 R^2) \qquad (26)$$

It means the force between two protons is 120 times of electrostatic force and is attraction appeared at R=1.001×10^{-13}cm. This is so-called strong interaction. Obviously it just is the electromagnetic interaction suffered from two times of CCE.

There must exist system precession for the two protons system, because they are spinning and attraction to each other. This precession is about the axis $\boldsymbol{\omega_t}$ which is passing though the mass center O as shown in Fig.10. Its angular velocity ω_t can be got as follows: The centripetal acceleration is: $\omega_t^2 R/2$, mass is m_p, the centripetal force is $120q^2/(4\pi\varepsilon_0 R^2)$. In terms of Newton's second law we have: $120q^2/(4\pi\varepsilon_0 R^2)= m_p\omega_t^2 R/2$, i.e.:

$$\omega_t^2 = 60q^2/(m_p\pi\varepsilon_0 R^3) = 60\times1.602\times10^{-38}/(\pi\times1.7\times10^{-27}\times8.85\times10^{-12}\times10^{-45}),$$ ω_t=1.426×10^{23} r/s,

its critical radius is: c/ω_t=2.1037×10^{-13}cm. At the place occupied by proton ($R/2$=0.5005×10^{-13}cm) its Lorentz factor is $[1-(0.5005/2.1037)^2]^{-1/2}$=1.0296≈1. So we can neglect its affect in above iterative calculation. However, beyond this critical cylinder, the proton will act repulsion to positive charge. In other words, the attraction between the two protons is only kept in the region of inside critical cylinder of this system precession.

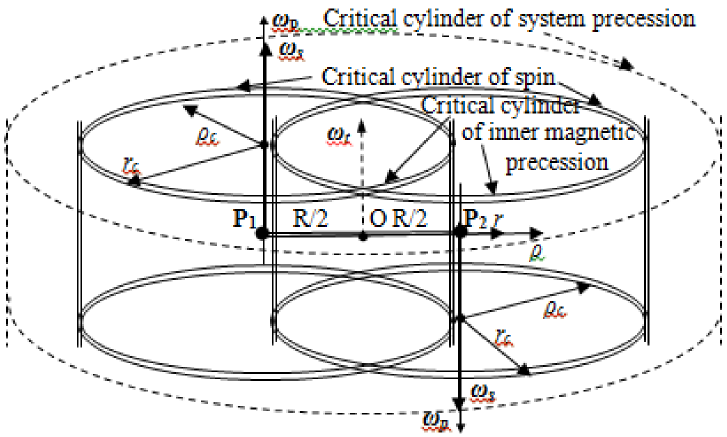


Fig.10. Critical cylinders of two protons system

Space-time exchange and linear velocity

As mentioned in first section, for OCC the linear velocity is not $\rho\omega=c\rho/\rho_c$ again but is $c^2/(\rho\omega)=c\rho_c/\rho$.

The proof is as follows: For writing simple, consider the first and last equations of (2) only.

They are:
$$\begin{cases} ds = \gamma(ds' + \rho\omega dt') \\ dt = \gamma(dt' + \dfrac{\rho\omega}{c^2} ds') \end{cases} \tag{27}$$

Note
$$\gamma = \frac{1}{\sqrt{1-\rho^2\omega^2/c^2}} \cdot \frac{c/(\rho\omega)}{c/(\rho\omega)} = \begin{cases} \dfrac{c}{\rho\omega} \dfrac{1}{\sqrt{c^2/(\rho^2\omega^2)-1}} \cdot \dfrac{i}{i} \\ \dfrac{c}{\rho\omega} \dfrac{1}{i\sqrt{1-c^2/(\rho^2\omega^2)}} \cdot \dfrac{i}{i} \end{cases} = \begin{cases} \dfrac{ic}{\rho\omega} \dfrac{1}{\sqrt{1-c^2/(\rho^2\omega^2)}} \\ \dfrac{ic}{\rho\omega} \dfrac{-1}{\sqrt{1-c^2/(\rho^2\omega^2)}} \end{cases} = \frac{ic}{\rho\omega}\gamma'$$

Where
$$\gamma' = \frac{\pm 1}{\sqrt{1-c^2/(\rho^2\omega^2)}} = \frac{\pm 1}{\sqrt{1-\rho_c^2/\rho^2}}, \quad i = \sqrt{-1} \quad \text{and} \quad \frac{\gamma}{\gamma'} = \frac{ic}{\rho\omega} = \frac{i\rho_c}{\rho} \tag{28}$$

Thus, equation (27) can be written as:
$$\begin{cases} ds = \gamma ds' + \gamma' icdt' \\ icdt = \gamma icdt' - \gamma' ds' \end{cases} \tag{29}$$

And can be denoted in complex form:
$$[ds, icdt] = [(\gamma ds' + \gamma' icdt'), (\gamma icdt' - \gamma' ds')] \tag{30}$$

For ICC, γ is real, γ' is imaginary, $(\gamma ds' + \gamma' icdt')$ is real, $(\gamma icdt' - \gamma' ds')$ is imaginary. Taking the real and imaginary parts of the two sides of (30) to be equal respectively, equation (29), i.e. (27) can be got.

For OCC, γ is imaginary, γ' is real, $(\gamma ds' + \gamma' icdt')$ is imaginary, $(\gamma icdt' - \gamma' ds')$ is real. Taking the real and imaginary parts to be equal respectively again, following equation (31) can be got.

$$\begin{cases} icdt = \gamma ds' + \gamma' icdt' \\ ds = \gamma icdt' - \gamma' ds' \end{cases} \tag{31}$$

Putting equations (27), (29) and (31) together, we have

$$\begin{cases} ds \xleftarrow{ICC} = \gamma ds' + \gamma' icdt' = \gamma(ds' + \rho\omega dt') = \xrightarrow{OCC} icdt \\ icdt \xleftarrow[ICC]{} = \gamma icdt' - \gamma' ds' = ic\gamma[dt' + (\rho\omega/c^2)ds'] = \xrightarrow[OCC]{} ds \end{cases} \tag{32}$$

It means that the space of (*ds'*+*ρωdt'*) in frame A' is contracted to space *ds* of frame A by real γ for ICC, but for OCC it is changed to time *icdt* by imaginary γ. On the other hand, the time ($dt'+\rho\omega ds'/c^2$) of frame A' is dilated to time *dt* of frame A by real γ for ICC, but for OCC it is changed to space *ds/*(*ic*) by imaginary γ. This is a natural law which has not been discovered till now, we call it space-time exchange, since the places of *ds* and *icdt* in eq. (32) is exchanged as the event point is changed from ICC to OCC. Furthermore, if ds'=0 (the event point is fixed in rotating frame A'), equation (32) becomes to:

$$\begin{cases} ds \xleftarrow{ICC} = \gamma\rho\omega dt' = \gamma' icdt' = \xrightarrow{OCC} icdt \\ icdt \xleftarrow[ICC]{} = \gamma icdt' = \xrightarrow[OCC]{} ds \end{cases}$$

Note that: $\dfrac{\gamma}{\gamma'} = \dfrac{ic}{\rho\omega} = \dfrac{i\rho_c}{\rho}$, we have:

for ICC: $\dfrac{ds}{dt} = \dfrac{\gamma\rho\omega dt'}{\gamma dt'} = \rho\omega = c\dfrac{\rho}{\rho_c}$, but for OCC: $\dfrac{ds}{dt} = \dfrac{\gamma icdt'}{\gamma' dt'} = \dfrac{-c^2}{\rho\omega} = -c\dfrac{\rho_c}{\rho}$. (33)

However, the direction of *ds/dt* must be the same for both ICC and OCC, to keep the rotational body from breaking. This means that the minus *γ*' must be taken, as plus *γ* has already been taken. Thus (33) becomes to:

for ICC: $\dfrac{ds}{dt} = \rho\omega = c\dfrac{\rho}{\rho_c}$, for OCC: $\dfrac{ds}{dt} = \dfrac{c^2}{\rho\omega} = c\dfrac{\rho_c}{\rho}$ the as the minus root of *γ*' is taken (34)

It means that the linear velocity v for OCC is no longer $\rho\omega$ but $c^2/(\rho\omega)=c\rho_c/\rho$. In fact this relation had been verified with several measurements made in last Century by some authors. They measured the linear velocity of electron's spin at different radial distance. To their surprise, the measured values (v) were all far less than light speed, say, at $\rho\approx 10^{-12}$cm, $v\approx 10^{6}$cm/s. In terms of $v=\rho\omega$, they got $\omega=v/\rho\approx 10^{18}$r/s, and found this value was only 10^{-8} of that could create its angular momentum of $\hbar/2$. So they had to think the spin angular momentum of electron is intrinsic and its spin is not a rotation about axis. Now we know the critical radius of electron's spin is $\rho_c=\rho v/c\approx 10^{-16}$cm, which is less than $\rho\approx 10^{-12}$cm, so the angular velocity is $\omega=c^2/(\rho v)$ $\approx 10^{26}$r/s, that is 10^8 times of $v/\rho\approx 10^{18}$r/s, and so is just the value to create its angular momentum of $\hbar/2$. This denotes the spin of electron is just a rotation about an axis. It is this rotation that creates its spin angular momentum. Based on $v=c^2/(\rho\omega)$, all things are reasonable for OCC! The spin theory of quantum mechanics denies the rotational essence of spin, repel the relativity for rotational frames, lots of important natural laws can't be revealed. The research of particle world can't go to ahead! It's the time to correct it.

Conclusion

There is space-time exchange, which makes the linear velocity of a rotation become to $c\rho_c/\rho$ for OCC. Denying the rotational essence, the spin theory of quantum mechanics is based on incorrect foundation.

There is CCE for every rotation, so the Coulomb's law isn't complete.

So-called strong interaction is just the CCE of electromagnetic interaction.

Lots of unsolved questions, such as the source of mass, dark matter, the source of quantum property of particles can be solved by relativity for rotational frames. We will give the details in another paper.

Knowing the essence of strong interaction, we have made an instrument with the weight of less than 2 Kg, which can decompose the nucleus of oxygen free radical. So it can be used to treat lots of diseases, such as cancer, arteriosclerosis, AIDS, COVID-19, etc. We will give the details in another paper.

References and notes:

[1] C. Møler, THE THEORY OF RELATIVITY, Clarendon Press Oxford 1972

[2] Yin Rui, Rotating Lorentz Transformation and Unification of Forces, B.U.A.A. Press, Beijing, 1997

[3] Yin Rui, Unification of Forces According to Relativity for Rotations, HADRONIC JOURNAL, Volume 23, Number 5, October 2000, pp. 487-549. (Note: page 497 should be between 492 and 493)

Acknowledgements

A special acknowledgment is due to Dr. C.N. Yang, Dr. H. T. Nieh and Dr. P. Lauterbur in the State University of New York at Stony Brook and Dr. R. A. Scheuing, Dr. T. C. Fang in the Grumman Aerospace Corporation. A special acknowledgment is due to Prof. B. Nordenström in Karolinska Medical Institute and Prof. Y. L. Xin in Chinese-Japanese Friendship Hospital .