World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:18, No:10, 2024

Critical Cylindrical Effect and Space-Time Exchange in Rotational Reference Frames of Special Relativity

Rui Yin, Ming Yin, Yang Wang

***Abstract*—**For a rotational reference frame of the theory of special relativity, the critical radius is defined as the distance from the axis to the point where the tangential velocity is equal to the speed of light, and the critical cylinder as the set of all points separated from the axis by this critical radius. Based on these terms, two relativistic effects of rotation are discovered: (i) the tangential velocity in the region of Outside Critical Cylinder (OCC) is not superluminal, due to the existence of space-time exchange; (ii) some of the physical quantities of the rotational body have an opposite mathematic sign at OCC versus those at Inside Critical Cylinder (ICC), which is termed as the Critical Cylindrical Effect (CCE). The laboratory experiments demonstrate that the repulsive force exerted on an anion by electrons will change to an attractive force by the electrons in precession while the anion is at OCC of the precession. 36 screenshots from four experimental videos are provided. Theoretical proofs for both space-time exchange and CCE are then presented. The CCEs of field force are also discussed.

***Keywords*—**Critical radius, critical cylindrical effect, special relativity, space-time exchange.

I. Introduction

ROTATION is the most basic form of motion in nature. For the fixed axis rotation, the tangential velocity *v*, angular velocity ω, and the radial distance *r* have the relation $v = r\omega$. Therefore, any rotation has a corresponding radial distance r_c, where *v* reaches the speed of light *c*:

$$r_c\omega = c, i.e., r_c = c/\omega$$

We call r_c the critical radius. All points with their radial distance being r_c form an infinitely long cylindrical surface are called the critical cylinder. The tangential velocity OCC has been thought to be superluminal, which is impossible. However, our experiments prove that there are opposite natural laws in the domain of OCC vs. the ICC.

II. Experimental Observation of Rotation Relativistic Effects

A. Experimental Scheme

When the spin magnetic moment (*M*) of a charged particle is not aligned with the external magnetic field (*B*), the *B* will reorient the *M* parallel to *B* through a precession process. The relationship between the precession angular velocity ω_m and *B* is $\omega_m = 2\pi\gamma B$, where γ is the gyromagnetic ratio. For free electrons, γ_e is 2.6667×10^{-10} (Hz/Tesla). Thus, with *B* being 0.12 Tesla, ω_m is 2.0106×10^{10} rad/s, and the corresponding critical radius r_c is approximately 1.5 cm, which allows the electric field force of the precession electrons to be readily observed.

B. Experimental Setup, Methods, and Results

A helical electrode with 15 mm in length and 2 mm in diameter is connected to the negative output terminal of a high DC voltage generator (HVG) with 1,800 V_{DC} output. The electrode is affixed to the resin surface of a single-sided copper-clad laminate board, which is itself secured in a plastic dish. The two ends of two U-type ferrite cores (Mn-Zn 2000) clamp the electrode, the resin plate, and the plastic dish together, while the other two ends are inserted into the exciting coil with 2×800 turns, as shown in Fig. 1: When the HVG is turned on, an abundance of free electrons will accumulate on the electrode surface.

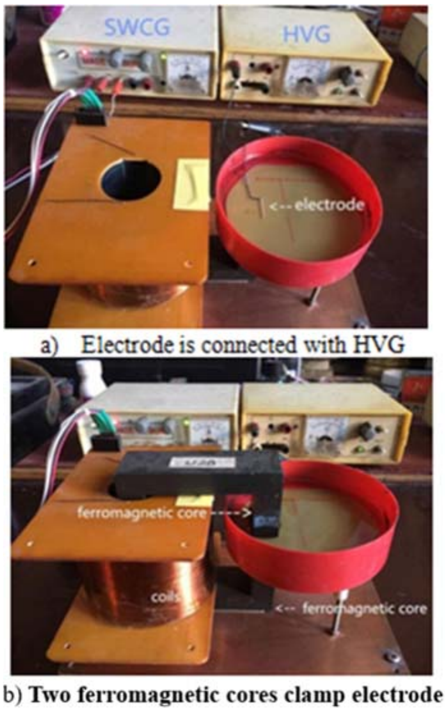

Fig. 1 The experimental setup

A square wave current generator (SWCG) with the 0.4 A to 0.6 A adjustable output current and 10 μS period (80% duty

Rui Yin is with Beihang University, Beijing, China 100191 (phone: +86-13051343464; e-mail: yr195@ buaa.edu.cn).
Ming Yin is with Beihang University, Beijing, China 100191 (e-mail: 2320314608@qq.com).
Yang Wang was with Beihang University, Beijing, China 100191.He is now with RF Lab (Hongkong) Limited, Hong Kong, China (corresponding author, phone: +86-13003429159 e-mail: thomasyang.wang@gmail.com).

cycle) feeds the coil, producing a magnetic field transferred to the electrode via two ferrite cores, causing the free electrons on the electrode surface to precession. By adjusting the magnitude of the square wave current, B passing through the electrons can be varied, thereby changing the r_c. Initially, B is set to 0.12 Tesla, resulting in a precession r_c of 1.492 cm for the electrons. A 20% carbon ink containing a high concentration of anionic surfactants (negatively charged ions) is used as the test charge.

To begin, warm water is added to the plastic dish, and a small quantity of ink is injected 1 cm to 1.3 cm to the right side of the electrode. Then, the HVG is turned on to generate electrons on the electrode. The ink is repelled rightward as illustrated in the four sequential screenshots from the video presented in Fig. 2 (b).

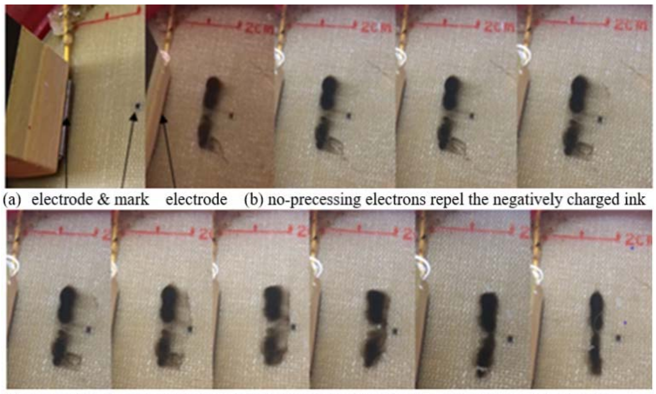

Fig. 2 Ten screenshots from the experimental video

Once the right edge of the ink is repelled to the black mark (the resin board's center), the SWCG is activated to induce precession of the electrons. Subsequently, the ink's left edge continues being repelled rightward, whereas its right edge begins being attracted leftward by the precession electrons. Fig. 2 (c) sequentially presents six screenshots from the video. The entire video is available on YouTube.com [1].

The experimental results demonstrate that the electric field force of precession electrons exists in OCC and is opposite in direction to that in ICC. This opposite electric field force in OCC is our newly discovered natural law.

To observe the change of the electric field force of the electrons on either side of r_c, a red line is drawn 1.5 cm away from the electrode in advance. The experiment is then repeated. Figs. 3 and 4 display video screenshots from the repeated experiment. Figs. 3 (a) and 4 (a) show two sequential screenshots demonstrating the repulsive force exerted on all ink by the electrons when no B is applied, repelling all ink rightward. Figs. 3 (b) and 4 (b) present five sequential screenshots after B is applied. The precession electrons attract the ink on the right side of red line, while the ink on the left side of the red line is gradually repelled rightward. This shows that procession electrons attract negative charges in OCC and repel them in ICC.

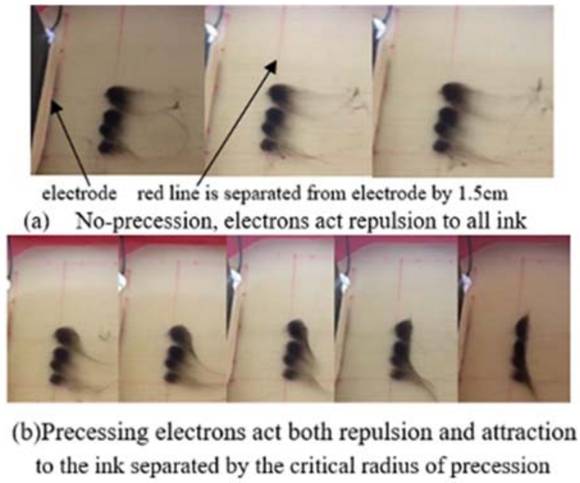

Fig. 3 The screenshots of the experimental video as B is 0.12 T and r_c is 1.5 cm

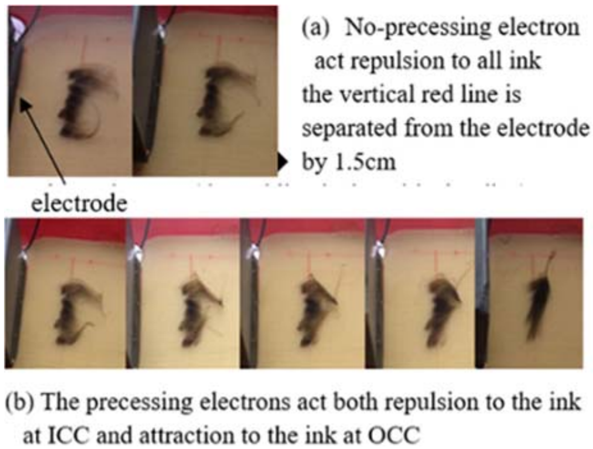

Fig. 4 Screenshots of the experimental video as B is 0.12 T and r_c is 1.5 cm

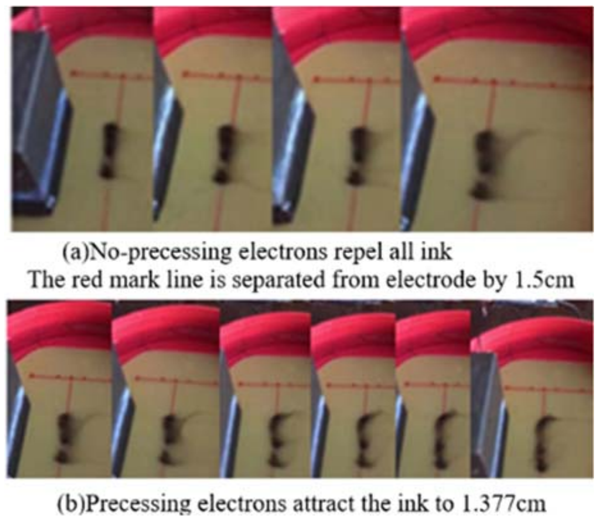

Fig. 5 Screenshots of the experimental video as B is 0.13 T and r_c is 1.377 cm

Furthermore, increasing B to 0.13 Tesla results in ω_m being

2.1728×10^{10} rad/s and r_c being 1.377 cm, respectively. Fig. 5 shows 12 sequential screenshots from the video. Fig. 5 (a) displays four screenshots of the ink moving to the right of the red line (1.5 cm away from the electrode), due to the repulsive force of non-precession electrons. Fig. 5 (b) presents eight sequential screenshots demonstrating that with precession electrons, the ink at the right of the red line is attracted leftward, eventually gathering at the right side of r_c (1.377 cm) from the electrode, while remaining left of the red line.

C. Experimental Results Discussion

This experiment demonstrates a newly discovered natural law: the electric field force of precession electrons exists in OCC but has the opposite direction to that ICC. In fact, many physical quantities of a rotating exhibit the opposite math signs in the OCC compared to the ICC. This reversal occurs when charges rotate, representing a relativistic rotational effect we term the Critical Cylinder Effect (CCE) that reveals the incompleteness of Coulomb's law discovered before the spin of electron was discovered.

Additionally, the observed critical radius indicates that the precession of electrons is a rotation with a definite axis and constant tangential velocity. Since only a rotating object can create precession when an external torque is applied, electron spin must be rotation with a fixed axis and constant angular velocity.

Furthermore, quantum mechanics postulates that the electric field force is transferred by photons, which means that electrons emit (virtual) photons and hit the negative ions, causing the momentum change of the negative ions; the changing rate of momentum is the force on the negative ions [2]. However, this fails to explain why photon exchanges would exert opposing forces on either side of the critical radius. Electric field force must interact with a medium rotating in sync, not (virtual) photons emitted by electron.

Existing electric field force in OCC means that the tangential velocity of electric field of the precession electron does not exceed the speed of light in OCC. In fact, the relation between v and ω of fixed axis rotation in OCC is no longer $v = r\omega$, but $v = c^2/(r\omega)$, which has not yet been discovered. The theoretical proof is in Section III.

III. Space-Time Exchange and Tangential Velocity of Rotation

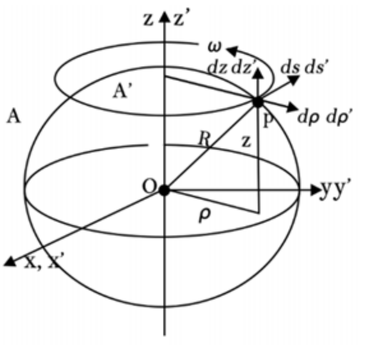

Fig. 6 Local reference frame of point P

We assume that the two reference frames A and A' rotate around the z(z') axis at an angular velocity of ω relative to each other, as shown in Fig. 6. Substituting the differentials of arc length, radial distance, axial distance, and time (ds, dρ, dz, dt) at the observed point P to the Cartesian coordinates and time (x, y, z, t), the Lorentz transformation and its inverse between the rotational frames take the following form [3], [4]:

$$\begin{cases} ds' = \gamma(ds - \rho\omega dt) \\ d\rho' = d\rho \\ dz' = dz \\ dt' = \gamma\left(dt - \frac{\rho\omega}{c^2} ds\right) \end{cases} \quad (1)$$

$$\begin{cases} ds = \gamma(ds' + \rho\omega dt') \\ d\rho = d\rho' \\ dz = dz' \\ dt = \gamma\left(dt' + \frac{\rho\omega}{c^2} ds'\right) \end{cases} \quad (2)$$

where

$$\gamma = \frac{1}{\sqrt{1 - \frac{\rho^2\omega^2}{c^2}}} \quad (3)$$

However, they are only valid for ICC. For OCC, with the $d\rho' = d\rho$ and $dz' = dz$ being kept, we only explore the first and last equations of (2). They are:

$$\begin{cases} ds = \gamma(ds' + \rho\omega dt') \\ dt = \gamma\left(dt' + \frac{\rho\omega}{c^2} ds'\right) \end{cases} \quad (4)$$

Note:

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

$$\begin{cases} \frac{ic}{\rho\omega} \cdot \frac{1}{\sqrt{1-c^2/(\rho^2\omega^2)}} \\ \frac{ic}{\rho\omega} \cdot \frac{-1}{\sqrt{1-c^2/(\rho^2\omega^2)}} \end{cases} = \frac{ic}{\rho\omega} \cdot \gamma', \text{ where } \gamma' = \frac{\pm 1}{\sqrt{1 - \frac{c^2}{\rho^2\omega^2}}} = \frac{\pm 1}{\sqrt{1 - \frac{\rho_c^2}{\rho^2}}}, \text{ and}$$

$$i = \sqrt{-1}.$$

So,

$$\frac{\gamma}{\gamma'} = \frac{ic}{\rho\omega} = \frac{i\rho_c}{\rho} \quad (5)$$

Then, (4) can be expressed as:

$$\begin{cases} ds = \gamma ds' + \gamma' icdt' \\ icdt = \gamma icdt' - \gamma' ds' \end{cases} \quad (6)$$

We denote (6) in complex number form:

$$[ds, icdt] = [\gamma ds' + \gamma' icdt', \gamma icdt' - \gamma' ds'] \quad (7)$$

Then, we have the property of each component shown in

Table I.

TABLE I
COMPONENTS PROPERTY

	γ	γ'	$\gamma ds' + \gamma' icdt'$	$\gamma icdt' - \gamma' ds'$
ICC	Real	Imaginary	Real	Imaginary
OCC	Imaginary	Real	Imaginary	Real

Taking the real and imaginary parts on both sides of (7) to be equal respectively, we get:

$$\begin{cases} ds \overset{ICC}{=\longleftarrow} \gamma ds' + \gamma' icdt' \overset{OCC}{\longrightarrow =} icdt \\ icdt \overset{ICC}{=\longleftarrow} \gamma icdt' - \gamma' ds' \overset{OCC}{\longrightarrow =} ds \end{cases} \tag{8}$$

With (8), for OCC, the space of (γds'+γ'icdt') in frame A' is transformed to time of frame A; and the time of (γicdt'-γ'ds') in frame A' is transformed to space of frame A. This is a natural law never be revealed yet, and we call it "space-time exchange".

We replace $\gamma = \gamma' ic/(\rho\omega)$ to (8), for OCC, we have:

$$\begin{cases} ds = -\gamma' \left[ds' + \frac{c^2}{\rho\omega} dt'\right] \\ dt = \gamma' \left[dt' + \frac{1}{\rho\omega} ds'\right] \end{cases} \tag{9}$$

Similarly, in terms of (1), we can get the corresponding transformation for OCC as follows:

$$\begin{cases} ds' = \gamma' \left[ds' - \frac{c^2}{\rho\omega} dt\right] \\ dt' = -\gamma' \left[dt' - \frac{1}{\rho\omega} ds\right] \end{cases} \tag{10}$$

However, for making (9) and (10) to be a pair of transformations, following principle must be kept: a pair of $(ds,dt)_{old}$ is transformed to (ds', dt') by (10), then this (ds', dt') is transformed to $(ds,dt)_{new}$ by (9), that must be equal to $(ds,dt)_{old}$.

For keeping this principle, add 1, 2, 3, 4 four subscripts to the γ' in (10) and (9), we have:

$$\begin{cases} ds = -\gamma_1'(ds' + \frac{c^2 dt'}{\rho\omega}) \\ dt = \gamma_2'(\frac{ds'}{\rho\omega} + dt') \end{cases}, \text{ and } \begin{cases} ds' = \gamma_3'(ds - \frac{c^2 dt}{\rho\omega}) \\ dt' = \gamma_4'(\frac{ds}{\rho\omega} - dt) \end{cases}$$

Then we express them in matrix form as:

$$\begin{bmatrix} ds \\ dt \end{bmatrix} = \begin{pmatrix} -\gamma_1' & -\gamma_1' c^2/(\rho\omega) \\ \gamma_2'/(\rho\omega) & \gamma_2' \end{pmatrix} \begin{bmatrix} ds' \\ dt' \end{bmatrix},$$
$$\begin{bmatrix} ds' \\ dt' \end{bmatrix} = \begin{pmatrix} \gamma_3' & -\gamma_3' c^2/(\rho\omega) \\ \gamma_4'/(\rho\omega) & -\gamma_4' \end{pmatrix} \begin{bmatrix} ds \\ dt \end{bmatrix}$$

Since $(ds,dt)_{new}$ must be equal to $(ds,dt)_{old}$, then:

$$\begin{bmatrix} ds \\ dt \end{bmatrix} = \begin{pmatrix} -\gamma_1' & -\gamma_1' c^2/(\rho\omega) \\ \gamma_2'/(\rho\omega) & \gamma_2' \end{pmatrix} \begin{pmatrix} \gamma_3' & -\gamma_3' c^2/(\rho\omega) \\ \gamma_4'/(\rho\omega) & -\gamma_4' \end{pmatrix} \begin{bmatrix} ds \\ dt \end{bmatrix}$$

It means:

$$\begin{pmatrix} -\gamma_1' & -\frac{\gamma_1' c^2}{\rho\omega} \\ \frac{\gamma_2'}{\rho\omega} & \gamma_2' \end{pmatrix} \begin{pmatrix} \gamma_3' & -\frac{\gamma_3' c^2}{\rho\omega} \\ \frac{\gamma_4'}{\rho\omega} & -\gamma_4' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

Solving this equation yields the following result:

$$\gamma_1' = -\gamma_2' = -\gamma_3' = \gamma_4'$$

Let $\gamma_1' = -\gamma_2' = -\gamma_3' = \gamma_4' = |\gamma'|$ and $-|\gamma'|$ separately, two groups of Lorentz transformations and their inverse for OCC are obtained:

Group 1: Transformation:

$$\begin{cases} ds' = -|\gamma'| \left(ds - \frac{c^2 dt}{\rho\omega}\right) \\ dt' = -|\gamma'| \left(dt - \frac{ds}{\rho\omega}\right) \end{cases} \tag{11a}$$

Inverse Transformation:

$$\begin{cases} ds = -|\gamma'|(ds' + \frac{c^2 dt'}{\rho\omega}) \\ dt = -|\gamma'|(dt' + \frac{ds'}{\rho\omega}) \end{cases} \tag{11b}$$

Group 2: Transformation

$$\begin{cases} ds' = |\gamma'| \left(ds - \frac{c^2 dt}{\rho\omega}\right) \\ dt' = |\gamma'| \left(dt - \frac{ds}{\rho\omega}\right) \end{cases} \tag{12a}$$

Inverse Transformation:

$$\begin{cases} ds = -|\gamma'|(ds' + \frac{c^2 dt'}{\rho\omega}) \\ dt = -|\gamma'|(dt' + \frac{ds'}{\rho\omega}) \end{cases} \tag{12b}$$

The tangential velocity (inverse) transformations given by these two groups are just the same:

$$u_s = \frac{ds}{dt} = \frac{ds' + \frac{c^2 dt'}{\rho\omega}}{dt' + \frac{ds'}{\rho\omega}} = \frac{\frac{ds'}{dt'} + \frac{c^2}{\rho\omega}}{1 + \frac{ds'}{dt'} \cdot \frac{1}{\rho\omega}} = \frac{u_s' + \frac{c^2}{\rho\omega}}{1 + \frac{u_s'}{\rho\omega}} \tag{13}$$

If the event point is fixed in frame A', i.e., $u_s' = 0$, then,

$$u_s = \frac{c^2}{\rho\omega} = c \cdot \frac{\rho_c}{\rho} \tag{14}$$

That is, the tangential velocity of frame A in OCC is no longer $\rho\omega$, but $c \cdot \rho_c/\rho$, which is still less than c and inverse proportional to radial distance ρ.

Quantum mechanics postulates that the spin of electron is intrinsic because the analogy to classical rotation falls apart when the tangential velocity of the surface of the electron is calculated with $v = r\omega$ only implied by such a spin. For instance, using classical mechanics, if we apply the equation $\frac{2}{5} mr^2\omega = \frac{1}{2}\hbar$, (where m, r, and ω are the mass, radius, and the angular velocity of the electron, $\hbar$ is reduced Plank constant), this tangential velocity according to $v = r\omega$ is superluminal ($v\ is\ 1.644 \times 10^{11}$ m/s) for the electron radius of 0.88×10^{-15} m. However, according to this equation, ω is $1.65 \times 10^{26}\ rad/s$, then, ρ_c is 1.82×10^{-18} m, which is the OCC case ($\rho_c = 1.82 \times 10^{-18}\ m \ll \rho = 0.88 \times 10^{-15}\ m$), v now is 6.41×10^5 m/s according to (14), which is not superluminal.

When the point is fixed in frame A', ds' is zero, (8) becomes:

$$\begin{cases} ds =\overset{ICC}{\longleftarrow} \gamma' icdt' \overset{OCC}{\longrightarrow} = icdt \\ icdt =\overset{ICC}{\longleftarrow} \gamma icdt' \overset{OCC}{\longrightarrow} ds \end{cases}$$

The tangential velocity of this point relative to frame A is:

For ICC:

$$\frac{ds}{dt} = \frac{\gamma' ic}{\gamma} = \rho\omega = c\frac{\rho}{\rho_c}$$

For OCC:

$$\frac{ds}{dt} = \frac{\gamma icdt'}{\gamma' dt'} = \frac{\pm|\gamma'|(-c^2)}{\gamma' \rho\omega} = \begin{cases} \frac{c^2}{\rho\omega},\ \gamma' = -|\gamma'| \\ -\frac{c^2}{\rho\omega},\ \gamma' = |\gamma'| \end{cases}$$

According to (14), $u_s = \frac{c^2}{\rho\omega}$, so the γ' must be $-|\gamma'|$. Thus, let:

$$v(\rho) = \begin{cases} c \cdot \frac{\rho}{\rho_c},\ \rho < \rho_c \\ c \cdot \frac{\rho_c}{\rho},\ \rho > \rho_c \end{cases}$$

$$\gamma(\rho) = \begin{cases} \frac{1}{\sqrt{(1-\rho^2/\rho_c^2)}}, \rho < \rho_c \\ \frac{-1}{\sqrt{(1-\rho_c^2/\rho^2)}}, \rho > \rho_c \end{cases} \tag{15}$$

The unified form of Lorentz transformation for rotational frames at both ICC and OCC is:

$$\begin{cases} ds' = \gamma(\rho)(ds - v(\rho)dt) \\ d\rho' = d\rho \\ dz' = dz \\ dt' = \gamma(\rho)\left(dt - \frac{v(\rho)}{c^2}ds\right) \end{cases} \tag{16}$$

and its inverse transformation is:

$$\begin{cases} ds = \gamma(\rho)(ds' + v(\rho)dt') \\ d\rho = d\rho' \\ dz = dz' \\ dt = \gamma(\rho)\left(dt' + \frac{v(\rho)}{c^2}ds'\right) \end{cases} \tag{17}$$

With (17), the transformations for other physical quantities can be derived. Below are some examples [4], [5]:

Mass:

$$m = \gamma(\rho)m'\left(1 + \frac{u_s' v(\rho)}{c^2}\right) \tag{18}$$

Energy:

$$w = \gamma(\rho)(w' + v(\rho)p_s') \tag{19}$$

Tangential momentum:

$$p_s = \gamma(\rho)\left(p_s' + \frac{v(\rho)w'}{c^2}\right) \tag{20}$$

Radial force F_ρ, axial force F_z and their composition force F_R:

$$F_{\rho\backslash z\backslash R} = \frac{F'_{\rho\backslash z\backslash R}}{\gamma(\rho)\left[1+\frac{u_s' v(\rho)}{c^2}\right]} = F'_{\rho\backslash z\backslash R}\gamma(\rho)\left[1 - \frac{u_s v(\rho)}{c^2}\right] \tag{21}$$

where u_s and u_s' are the tangential velocity of the acceptor in frame A and A', respectively.

IV. Critical Cylinder Effect of Electric Field Force

The transformations of the space-time coordinates, mass, energy momentum, and force all have γ(ρ) or 1/γ(ρ), and γ(ρ) is minus at OCC but plus at ICC, so these physical quantities will be minus at OCC but plus at ICC. This is the most important and unrecognized relativistic effect, which we call the Critical Cylinder Effect (CCE). Here, the CCE of electric field force for spin-charged particle is discussed.

We assume that the charged particle q_1 without displacement in the laboratory frame spins around the z-axis with the angular velocity ω at the coordinate origin O in Fig. 6, and the test charge q_2 is at point P. The distance from q_1 to q_2 is: $R = (\rho^2 + z^2)^{1/2}$. We take the laboratory as frame A, the spin of q_1 as frame A'. Only in A' the particle q_1 has neither displacement nor rotation and is truly at rest, and its force acted on the test charge q_2 is the real electrostatic force denoted as F_R', which is also unrelated with the state of motion of the test charge q_2. According to (21), F_R' is transformed into frame A, we have:

$$F_R = \frac{F_R'}{\gamma(\rho)\left[1+\frac{u_s' v(\rho)}{c^2}\right]} = F_R'\gamma(\rho)\left[1 - \frac{u_s v(\rho)}{c^2}\right] \tag{22}$$

where u_s' and u_s are the tangential velocity of the test charge q_2 relative to the spin of q_1 in frame A' and A, respectively. This means that in frame A, the force of the spin-only q_1 acting on the test charge q_2 is related to the motion state of q_2. If q_2 in frame A has no displacement, i.e., u_s = 0, (22) becomes $F_R = \gamma(\rho)F_R'$, that is:

$$\frac{F_R}{F_R'} = \gamma(\rho) = \begin{cases} \left(1 - \frac{\rho^2}{\rho_c^2}\right)^{-\frac{1}{2}} \\ -\left(1 - \frac{\rho_c^2}{\rho^2}\right)^{-\frac{1}{2}} \end{cases} \tag{23}$$

This relationship is called the first kind of CCE. It means F_R will change direction when q_2 changes its location from ICC to OCC, and as $\rho \to \rho_c$, F_R becomes very strong, as shown in Fig. 7. This is the source of so-called strong interaction between protons in the nucleus. The strong force only appears at 10^{-15} m [6], so it can be determined that the critical radius of the proton's spin is on the order of 10^{-15} m.

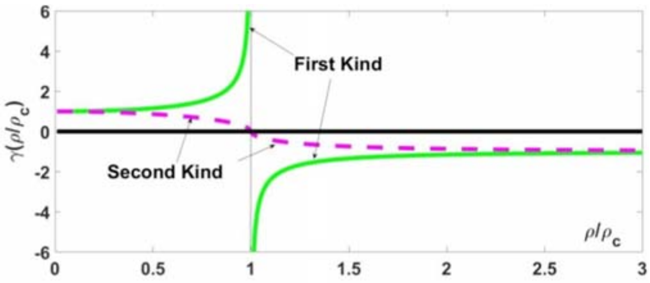

Fig. 7 Two kinds of CCEs

If q_2 is synchronously rotating with the q_1, that is, $u_s' = 0$, (22) becomes:

$$F_R = \frac{F_R'}{\gamma(\rho)} \tag{24}$$

This is the second kind of CCE. It means when $\rho \to \rho_c$, F_R will become very weak, and when q_2. changes its location from ICC to OCC, F_R will cross zero and change direction, as shown in Fig. 7. This is the source of so-called weak interaction.

V. Experimental Results Explanation

A. Incompletion of Coulomb's Law

Coulomb's law is about the electrostatic force and was discovered in 1780s without the concept of electron spin [7]. So, Coulomb's force is not static since it stays at the lab frame instead of the spin frame where the real electrostatic force, denoted as F_R', stays. Here, let us denote Coulomb's force as F_c.

The Coulomb's law is valid only for the distance of R greater than 10^{-12}m where $\gamma(\rho)$ is -1. The relationship between F_R' and F_c is as follows according to (22):

$$F_R' = \frac{F_c}{\gamma(\rho)} = -\frac{q_1 q_2}{4\pi\epsilon_0 R^2} \tag{25}$$

where, F_c is:

$$F_c = \frac{q_1 q_2}{4\pi\epsilon_0 R^2} \tag{26}$$

From (25), we can draw the following conclusion for F_R':

(a) Same/opposite sign particles attract/repel with each other.
(b) Same quantity as F_c, but opposite math sign as that of F_c.

Moreover, for ρ being very close to ρ_c, (26) is no longer valid for F_c, and should be modified as:

$$F_c = -\frac{q_1 q_2}{4\pi\epsilon_0 R^2}\gamma(\rho) \tag{27}$$

In general, q_2 is neither at rest nor synchronously rotating with q_1 i.e., $us \neq v(\rho) \neq 0$, F_c can be denoted as two parts according to (22):

$$F_c = F_R'\gamma(\rho) - F_R'\gamma(\rho)\frac{u_s v(\rho)}{c^2} = F_e + F_m \tag{28}$$

where, F_e is the electric field force:

$$F_e = F_R'\gamma(\rho) = -\frac{q_1 q_2}{4\pi\epsilon_0 R^2}\gamma(\rho) = q_2 E_s \tag{29}$$

where, E_s is the electric field of q_1:

$$E_s = -\frac{q_1}{4\pi\epsilon_0 R^2}\gamma(\rho) \tag{30}$$

and, F_m is the magnetic field force:

$$F_m = -F_R'\gamma(\rho)\frac{u_s v(\rho)}{c^2} = \frac{q_1 q_2}{4\pi\epsilon_0 R^2}\gamma(\rho)\frac{u_s v(\rho)}{c^2} = q_2 B_s \tag{31}$$

where, B_s is the magnetic field of q_1:

$$B_s = \frac{q_1}{4\pi\epsilon_0 R^2}\gamma(\rho)\frac{u_s v(\rho)}{c^2} = \frac{q_1}{4\pi R^2}\mu_0\gamma(\rho)u_s v(\rho) \tag{32}$$

For protons, with q_1 being 1.602×10^{-19} Coulomb, at the location R (i.e., ρ) being $0.999\rho_c$, B_s is 1.07×10^{14} Tesla. At the location R (i.e., ρ) being $1.001\rho_c$, $B_s = -1.08\times10^{14}$ T. Thus, in lab frame, the spin-only q_1 possesses both electric field E_s and magnetic field B_s. Near the critical radius, B_s is on the order of 10^{14} Tesla and will change direction from ICC to OCC. This cannot be given by spin magnetic moment. On the other hand, Coulomb's electric field is neither the real electrostatic field nor the complete electric field E_s of spinning charged particle, it only is the part of E_s at $\rho >> \rho_c$.

Note that the u_s in (22) is the tangential component of the velocity u of q_2 relative to the spin of q_1 in frame A. Even if u does not change, when the direction of the spin axis of q_1 is changing, u_s and the force on q_2 will be different, and the tendency of q_2 's motion is naturally different. Without controlling the direction of the spin axis of q_1, the future position of q_2 is naturally uncertain. This generates the probability wave property of particles in quantum mechanics.

B. The Explanation of Our Experimental Result

q_1 is spinning and precession while q_2 (ink) is spinning only. To obtain F_c, we must transform F_R' from the spin frame to the procession frame, then to the lab frame:

$$F_c = F_s\gamma(\rho)\gamma(r)\left[1 - \frac{v(\rho)u_{sp}'}{c^2}\right]\left[1 - \frac{v(r)u_{pl}}{c^2}\right] \tag{33}$$

where, for spin frame:

$$v(\rho) = \begin{cases} \rho\omega_s', \rho < \frac{c}{\omega_s'} = \rho_c \\ \frac{c^2}{\rho\omega_s'}, \rho > \frac{c}{\omega_s'} = \rho_c \end{cases}, \gamma(\rho) = \begin{cases} \frac{1}{\sqrt{1-(\frac{v(\rho)}{c})^2}}, \rho < \rho_c \\ -\frac{1}{\sqrt{1-\left(\frac{v(\rho)}{c}\right)^2}}, \rho > \rho_c \end{cases}$$

for precession frame:

$$v(r)=\begin{cases} r\omega_m, r<\dfrac{c}{\omega_m}=r_c \\ \dfrac{c^2}{r\omega_m}, r>\dfrac{c}{\omega_m}=r_c \end{cases}, \gamma(r)=\begin{cases} \dfrac{1}{\sqrt{1-(\frac{r}{r_c})^2}}, r<r_c \\ -\dfrac{1}{\sqrt{1-(\frac{r_c}{r})^2}}, r>r_c \end{cases}$$

Here, ρ and r are the radial distance of the spin axis and processing axis from q_1 to q_2, respectively; ρ_c and r_c are the critical radius of the spin and precession, respectively; u'_{sp} and u_{pl} are the tangential velocity of q_2 with respect to the precession frame and lab frame of q_1, respectively; ω'_s and ω_m are the angular velocity of q_1 in spin frame and precession frame, respectively.

Since $v(\rho)\ll c$, $v(r)\ll c$, meanwhile, the diffusion velocity of ink is much smaller than the tangential velocity of precession, i.e., $u'_{sp}\approx 0$, $u_{pl}\approx 0$, we have:

$$F_c = F'_R\gamma(\rho)\gamma(r) = -\frac{q_1 q_2}{4\pi\varepsilon_0 R^2}\gamma(\rho)\gamma(r) \quad (34)$$

For our lab experiment, ρ_c is about $10^{-18}\ m$ and r_c is about $1.5\times 10^{-2}\ m$. For the region with $R>1\times 10^{-18}\ m$, we have $\gamma(\rho)\approx -1$, then we have:

$$F_c \approx -F'_R\gamma(r) = \frac{q_1 q_2}{4\pi\varepsilon_0 R^2}\gamma(r) \quad (35)$$

Now, for the ink on the right side of the red line (r_c), they are at the location where $R=r>r_c$, then $\gamma(r)<0$, and $F_c<0$, which causes the ink being attracted to the leftward; for the ink on the left side of the red line (r_c), they are at the location where $R=r<r_c$, then $\gamma(r)>0$, and $F_c>0$, which causes the ink to be repelled to the rightward.

VI. Conclusions

In conclusion, the study identifies undiscovered relativistic effects associated with rotational reference frames, specifically in relation to the critical cylinder. The findings reveal that in the OCC, tangential velocities remain subluminal due to space-time exchange, and that physical quantities exhibit opposing math signs between OCC and ICC, a phenomenon termed as the Critical Cylinder Effect (CCE). These effects were experimentally validated through laboratory experiments demonstrating the reversal of the force exerted by electrons on an anion when it is located at the OCC of precession. Theoretical proofs were provided to support these observations, further expanding our understanding of relativistic effects in rotational systems, with potential implications for the behavior of field forces. In addition, the sources of strong and weak interactions are revealed, and the real electrostatic force formula is provided.

References

[1] www.youtube.com/watch?v=GJX-3AosxZk&t=7s
[2] C.N. Yang, R.L. Mills: "Conservation of Isotopic Spin and Isotopic Gauge Invariance", pp.191-195, Physics Review (96)1,
[3] C. Moller, "The Theory of Relativity" Clarendon Press, Oxford, 1972, pp. 15–64.
[4] Yin Rui, "Rotating Lorentz Transformation and unification of Forces" BUAA Press, Beijing, 1997, pp. 123–135.
[5] Yin Rui, "Unification of Forces According to Relativity for Rotations", Hadronic Journal, Vol. 23, No. 5, October 2000.
[6] Harald Fritzsch: "QUARKS The Stuff of Matter", Basic Books, INC., Publisher, New York, 1983.
[7] G. Spavieri, et al: "Physical implications of Coulomb's Law", Metrologia, October 2004.

Rui Yin graduated from electronic engineering department of Beihang University, Beijing, China in 1960. Since then, he has worked at Beihang University as lecture, associate professor, and professor. From 1982 to 1983, as a visiting scholar presented the research work about MRI with DR. Paul Lauterbur at State University of New York at Stony Brook. The research interests are digital signal processing, MRI, and Magnetic Resonance Therapy (MRT) and relativistic effect of rotation.