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The First Law of Newton. Formula and Consequences: Changes in Weight and Forward Motion of Rotating Bodies

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ABSTRACT

The aim of this work is to show that the first Newton's law (law of inertia) is a manifestation of the law of conservation of angular momentum in the physical vacuum. The force of inertia arises in a body as a result of a change in the angular momentum of the body. The change in the angular momentum can emerge when changing the characteristics of spins of virtual photons created by quantum objects constituting the body. Due to the law of conservation of angular momentum a change in the angular momentum results in emergence of the processes compensating this change. One of these compensating processes is the emergence of force of inertia influencing the velocity of quantum objects constituting the body. Another compensating process is the emergence of rotation of these objects. Both these processes are observed in experiments.

The force of inertia may arise in rotating bodies as rotation of body influences the characteristics of spins of virtual photons created by quantum objects of rotating body. If the force is directed along the vector of gravitation, the weight of rotating body is increased. If the force is directed against the vector of gravitation, the weight of rotating body is decreased. If the force is directed perpendicular to the vector of gravitation, the body is moving along the Earth surface. All these phenomena are observed in experiments.

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Introduction

Translated from Latin, Newton's first law reads [1]: "*Every object perseveres in its state of rest, or of uniform motion in a right line, except insofar as it is compelled to change that state by forces impressed thereon*". The Newton's first law still has no mathematical description and a convincing physical model.

The existence of property of an object to persevere *"in its state of rest, or of uniform motion in a right line"* indicates the existence of a physical process supporting "*state of rest, or of uniform motion in a right line*". It is shown in this work that this physical process is based on the law of conservation of angular momentum and related to the properties of virtual photons created by quantum objects constituting the bodies. Besides the properties of these virtual photons determine the following phenomena: the rotation of bodies moving with acceleration, changes in weight and forward motion of rotating bodies.

The virtual photons were introduced in 1949 by Nobel laureate R. Feynman for the denotation of force fields in his diagrams [2]. The virtual photons in his diagram are accomplishing electric and magnetic interactions. The properties of virtual photon are similar in many ways to the properties of photon transferring electromagnetic interaction as well. In classical physics, a free object (which is not subjected to external forces and thus moves uniformly and rectilinearly) cannot emit or absorb another particle since in these processes the principles of conservation would not hold. In quantum physics, if one were to accept Heisenberg's inequalities, the principles of the conservation of energy and momentum are not violated since the energy and momentum of a particle are living for a short time Δt in the area Δx determined with uncertainties ($\Delta\varepsilon$) and (Δp), respectively [3]. However, Heisenberg's inequalities do not include a variation in the determination of the virtual particles' spin; therefore, the creation of a virtual photon (having spin) by a quantum object (which is not subjected to external forces) without changing the value of its own spin violates the principle of conservation of angular momentum. However, there will be no violation of the principle of conservation of angular momentum if the interaction of the quantum object with the physical vacuum that has an intrinsic degree of freedom (i.e., spin) takes place. A group of physicists, including M. Planck, A. Einstein, and O. Stern, made the first step towards the physical vacuum having intrinsic degrees of freedom supposing existence in it of the atomic oscillator with energy $h\nu / 2$ (h is Planck constant) [4,5]. Later, this energy was called "zero-point energy". Thus, the virtual photons introduced by Feynman may be considered as spin vortices in the physical vacuum characterized by "zero-point energy" [6].

In this case there can be used the results of investigation by H. Li and others [7]: "We report the quantized superfluid vortex filaments induced by the axial flow effect". Really, the superfluid medium in investigation by H. Li characterized by intrinsic angular momentum is similar to the physical vacuum characterized by "zero-point energy". Thus, it follows from the investigation by H. Li that the motion (at velocity $\mathbf{u}$) of quantum object can be followed by "quantized superfluid vortex filaments", in particular, by spin vortex (virtual photon). One of the main properties of spin vortex is the precession motion (with frequency $\boldsymbol{\omega}_\nu$) of its spin $\mathbf{S}_\nu$. Consequently, the following relation exists

$$\mathbf{u} \sim \boldsymbol{\omega}_\nu . \quad (1)$$

The properties of virtual photon are similar in many ways to the properties of photon transferring electromagnetic interaction as well. The main difference between them is the difference between values of their angles of deflection β (the angle between vectors $\mathbf{S}_\nu$ and $\mathbf{u}$). The angle of deflection for photon equals $\pi / 2$, that is, $\sin\beta = 1$ [8]. At the same time in virtual photon [6]

$$\sin\beta = u / c , \quad (2)$$

where c is the speed of light.

Note: It follows from Eq. (2) that when the speed of virtual photon is equal to the speed of light, the irradiation of photon by quantum object takes place. This effect is observed and called "Cherenkov effect" [9].

The schematic image of virtual photon created by negatively charged quantum object is presented in Figure 1 (in detail, see Figure 2).

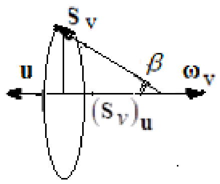

Figure 1: The schematic image of a virtual photon. $\boldsymbol{\omega}_\nu$ is the frequency of precession of spin $\mathbf{S}_\nu$, β is the angle of deflection, $\mathbf{u}$ is the velocity. $(\mathbf{S}_\nu)_\mathbf{u}$ is a projection of $\mathbf{S}_\nu$ on direction $\mathbf{u}$.

It follows from Figure (1) and Eqs (1)-(2) that the projection of spin $\mathbf{S}_\nu$ on direction $\mathbf{u}$ ($-\boldsymbol{\omega}_\nu$) is determined by expression

$$\left|(\mathbf{S}_\nu)_\mathbf{u}\right| = \left|-\eta S_\nu \cos\beta\right| = S_\nu\sqrt{1 - u^2 / c^2} , \quad (3)$$

where η is a factor depending on charge of quantum object: $\eta = 1$ for positively charged quantum object,

$\eta = -1$ for negatively charged quantum object (in detail see Section 1).

The change in the value of velocity **u** means the change in the projection of spin of virtual photon created by quantum object on its velocity, that is, it means the change in the angular momentum of the system: quantum object-virtual photon. Due to the principle of conservation of angular momentum this change in the value of projection of spin of virtual photon results in emergence of processes that should compensate for this change. Let us consider these processes in case of change in u by amount Δu. According to Eq. (3), $\Delta(\mathbf{S}_v)_\mathbf{u}$ is determined as

$$\Delta\left|(\mathbf{S}_v)_\mathbf{u}\right| = S_v\left(\sqrt{1-(u+\Delta u)^2/c^2} - \sqrt{1-u^2/c^2}\right). \quad (4)$$

The following processes compensate for the change in the projection of spin of virtual photon created by quantum object on its velocity.

- The rotation with angular momentum $\mathbf{J} = -\Delta(\mathbf{S}_v)_\mathbf{u}$ of the system: quantum object-virtual photon. This method of compensation explains the following physical phenomenon: the rotation of object performing accelerated motion, in detail see Section 3.
- The emergence of force $\mathbf{F}_u$ causing the change in velocity and compensating in this way the value $\Delta\left|(\mathbf{S}_v)_\mathbf{u}\right|$ (see Eq. 4)).

$$\mathbf{F}_\mathbf{u} = \gamma_s \partial\left|(\mathbf{S}_v)_\mathbf{u}\right| / \partial t, \quad (5)$$

or using Eq. (3)

$$\mathbf{F}_\mathbf{u} = -\mathbf{u}\gamma_s S_v / \left(c^2\sqrt{1-u^2/c^2}\right)\partial u/\partial t, \quad (6)$$

where $\gamma_s > 0$ is a factor of proportionality.

Thus, the force $\mathbf{F}_u$ performs stabilization action on the velocity of quantum object and it is the force of inertia in the system: quantum object-virtual photon. (See in detail Section 2).

The compensating process (Eqs (5)-(6)) determines the following phenomena as well: the forward motion of a rotating bodies and the change in the weight of rotating bodies (Section 4).

1. The Properties of Virtual Photons

According to the theory of gyroscope, moment M acting on processing spin $\mathbf{S}_v$ of object in an undisturbed state is related to frequency $\boldsymbol{\omega}_v$ of its precession as [10]

$$\mathbf{M} = \boldsymbol{\omega}_v \times \mathbf{S}_v. \quad (7)$$

According to Feynman hypothesis, the virtual photon has electric dipole moment $\mathbf{d}_v$ and its properties are similar to the analogous properties of photon transferring electromagnetic interaction as well. Consequently, the following is valid [6]

$$\mathbf{d}_v \uparrow\uparrow \mathbf{S}_v. \quad (8)$$

The electric field of quantum object acts on a virtual photon as on electric dipole. Consequently, with taking into account Eqs (1), (7), (8) and that virtual photon follows after the quantum object we obtain

$$\boldsymbol{\omega}_v \uparrow\uparrow \eta\mathbf{u}, \quad (9)$$

$$\eta = \begin{cases} 1, & \text{for positively charged quantum object} \\ -1, & \text{for negatively charged quantum object} \end{cases} \quad (10)$$

In accordance with the results of experiments by Stern-Gerlach about quantization of value of spin $\mathbf{S}_q$ of quantum object in direction of motion **u**: it follows that $\mathbf{S}_q \parallel \mathbf{u}$ [11].

From this condition, with taking into account Eqs (7) and (9)-(10), we should suppose:

$$\mathbf{S}_q \uparrow\uparrow \boldsymbol{\omega}_v. \quad (11)$$

The detailed schematic images of characteristics of virtual photons created by positive electrically charged and negative electrically charged quantum objects are given in Figure 2. $\boldsymbol{\omega}_v$ is the frequency of precession of spins $\mathbf{S}_v$; $\mathbf{d}_v$ are electric dipole moments; β is a deflection angle; **u** is a velocity of quantum object.

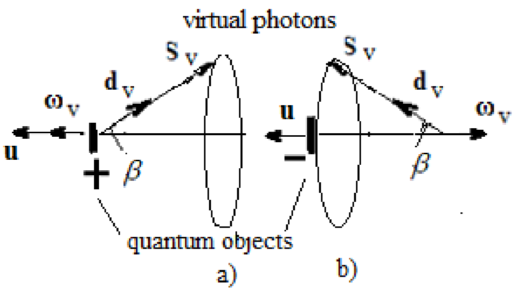

Figure 2: Schematic images of virtual photons produced by positively charged (variant **a**) and by negatively charged (variant **b**) quantum objects. $\boldsymbol{\omega}_v$ are frequencies of precession of spins $\mathbf{S}_v$; $\mathbf{d}_v$ are electric dipole moments; β are deflection angles; **u** are velocities of quantum objects.

The following equation for projection $(\mathbf{S}_v)_\mathbf{u}$ of the spin $\mathbf{S}_v$ on velocity **u** follows from Figure 2

$$(\mathbf{S}_v)_\mathbf{u} = -\eta S_v \cos\beta . \qquad (12)$$

Or with taking into account equality $\sin\beta = u/c$ (Eq. (2))

$$(\mathbf{S}_v)_\mathbf{u} = -\eta S_v \sqrt{1-u^2/c^2} . \qquad (13)$$

2. The Force Acting on a Nonrotating Body Performing Forward Accelerated Motion. The Force of Inertia

Let us consider two cases of the forward accelerated motion of nonrotating quantum object with arbitrary charge.

Case 1: Only the value of velocity of motion is changed.

According to Eq. (13), the change in the value of speed u causes the change in projection $(\mathbf{S}_v)_\mathbf{u}$ of the spin $\mathbf{S}_v$ on velocity **u,** that is, the change (in direction **u)** in the angular momentum of the system: quantum object-virtual photon. Due to law of conservation of angular momentum force $\mathbf{F}_u$ emerges causing the change in speed u and restoring in this way the value $(\mathbf{S}_v)_\mathbf{u}$ (see also Eq. (5)). $\mathbf{F}_\mathbf{u} = \gamma_s \partial \left|(\mathbf{S}_v)_\mathbf{u}\right| / \partial t$. Using in the latter expression Eq. (13) we obtain

$$\mathbf{F}_\mathbf{u} = -\mathbf{u}\gamma_s \left|\eta S_v / \left(c^2\sqrt{1-u^2/c^2}\right)\right| \partial u/\partial t . \qquad (14)$$

Force $\mathbf{F}_\mathbf{u}$ is aligned with velocity **u** under its decrease ($\partial u/\partial t < 0$) and is directed against velocity **u** under its increase ($\partial u/\partial t > 0$). That is, force $\mathbf{F}_\mathbf{u}$ performs a stabilizing effect and consequently it ensures the implementation of the first law of Newton.

Case 2: The direction of velocity of motion of quantum object is changed.

For example, the velocity $\mathbf{u}_n$ is the new direction of velocity **u**. Due to Eqs (9)-(10) this situation can be interpreted as follows: the initial frequency of precession $\boldsymbol{\omega}_v \,||\, \mathbf{u}$ of spin $\mathbf{S}_v$ changes by frequency of precession $\boldsymbol{\omega}_{vn} \,||\, \mathbf{u}_n$. It can be supposed that a change in the velocity is performed in two stages: at the first stage, the speed changes by amount -u; at the second stage the speed changes by amount $+u_n$. Consequently, the total force of inertia **F** can be represented by sum: $\mathbf{F} = \mathbf{F}_\mathbf{u} + \mathbf{F}_{\mathbf{u}_n}$. $\mathbf{F}_\mathbf{u}$ is determined by Eq. (14); $\mathbf{F}_{\mathbf{u}_n}$ is determined by a similar equation $\mathbf{F}_{u_n} = -\mathbf{u}_n\gamma_s \left|\eta S_v / \left(c^2\sqrt{1-u_n/c^2}\right)\right| \cdot \partial u_n/\partial t$.

Thus, force **F** is determined as

$$\begin{aligned}\mathbf{F} = &-\mathbf{u}\gamma_s \left|\eta S_v / \left(c^2\sqrt{1-u^2/c^2}\right)\right| \cdot \partial u/\partial t \\ &-\mathbf{u}_n\gamma_s \left|\eta S_v / \left(c^2\sqrt{1-u_n/c^2}\right)\right| \cdot \partial u_n/\partial t\end{aligned} . \qquad (15)$$

Graphical images of forces **F**, $\mathbf{F}_\mathbf{u}$ and $\mathbf{F}_{\mathbf{u}_n}$ are given in Figure 3.

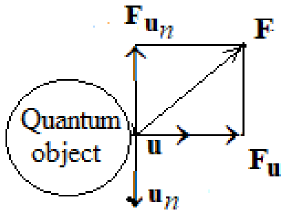

Figure 3: Graphical Images of forces of inertia: force $\mathbf{F}_{\mathbf{u}}$ caused by the disappearance of velocity $\mathbf{u}$, force $\mathbf{F}_{\mathbf{u}_n}$ caused by appearance of velocity $\mathbf{u}_n$, $\mathbf{F}$ is a resulting force.

Thus, the force of inertia emerges as a result of the action of the law of conservation of angular momentum. The change in the projection of spin of virtual photon on its velocity means the change in the angular momentum of the system: quantum object - virtual photon. The force of inertia influences the velocity so that the angular momentum value could be restored [12,13].

3. The Rotation of Object Performing Accelerated Forward Motion

Let us consider the motion of electron whose speed changes from $\mathbf{u}_1$ to $\mathbf{u}_2$ ($\mathbf{u}_1 \rightarrow\rightarrow \mathbf{u}_2$), see Figure 4. In this case, according to Eqs (12)-(13), the projection (on velocity) of precessing spin $\mathbf{S}_v$ of virtual photon created by the electron is changed by value ΔS_v determined as

$$\Delta S_v = \left| S_v \cos\beta_2 - S_v \cos\beta_1 \right| = S_v \left| \sqrt{1-u_2^2/c^2} - \sqrt{1-u_1^2/c^2} \right| . \qquad (16)$$

The value $\Delta\mathbf{S}_v$ is equal to a change in the angular momentum of accelerated moving system: electron-virtual photon. Due to the law of conservation of angular momentum the rotation of system electron-virtual photon emerges. The angular momentum $\mathbf{J}$ related to arising rotation is equal to $\Delta\mathbf{S}_v$ and orients as $\Delta\mathbf{u} = \mathbf{u}_2 - \mathbf{u}_1$

$$\mathbf{J} = \left(\Delta\mathbf{u} / |\Delta u| \right) \Delta S_v . \qquad (17)$$

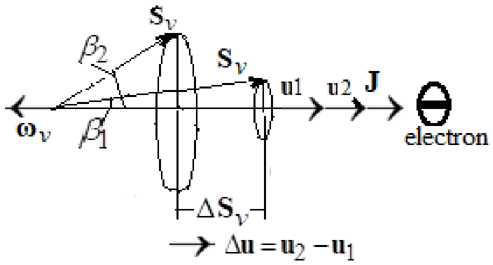

Figure 4: Schematic image of virtual photon created by electron. $\boldsymbol{\omega}_v$ is the frequency of precession of spin $\mathbf{S}_v$; $\Delta\mathbf{S}_v$ is the change in spin projection; β_1 and β_2 are angles of deflection corresponding to the velocities $\mathbf{u}_1$ and $\mathbf{u}_2 (u_2 > u_1)$; $\mathbf{J}$ is an angular momentum relating to rotation of the system: electron-virtual photon.

This phenomenon was observed in experiments by V. N. Zatelepin and D.S. Baranov in 2019 [14].

The condition (17) in the above considered examples is determined by the properties of moving electron. Let us consider the case when a positively charged particle (positron) is moving (Figure 5).

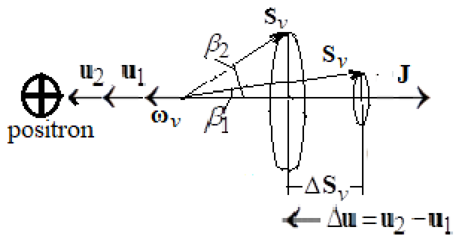

Figure 5: Schematic image of virtual photon created by positron. $\boldsymbol{\omega}_v$ is the frequency of precession of spin $\mathbf{S}_v$; $\Delta\mathbf{S}_v$ is the change in spin projection; β_1 and β_2 are angles of deflection corresponding to the velocities $\mathbf{u}_1$ and $\mathbf{u}_2$ $(u_2 > u_1)$; $\mathbf{J}$ is angular momentum relating to the rotation of system: positron-virtual photon.

In this case Eq. (16) is valid as well. But according to Eqs (9)-(10) and (12)-(13), the following Condition holds true

$$\mathbf{J} = -\left(\Delta\mathbf{u} / |\Delta u| \right) \Delta S_v . \qquad (18)$$

In the general case, at any charge of quantum object from Eqs (17)-(18) we have: $\mathbf{J} = -\eta\left(\Delta\mathbf{u}/|\Delta u|\right)\Delta S_v$. Essentially, the latter equation can be considered as a manifestation of Einstein-de Haas effect [15]: the rotation of body at reorientation of spins of quantum objects constituting the body.

4. The Change in the Weight and the Forward Motion of Rotating Ferromagnet

4.1. The Properties of Rotating Ferromagnet

Let us consider the characteristics of “free” electrons in a ferromagnet. Let us assume that in the rest state the frequency of precession of spin of virtual photon created by the “free” electron equals $\boldsymbol{\omega}_{v1}$ and its velocity equals $\boldsymbol{\upsilon}$.

The rotation of ferromagnet with angular velocity $\boldsymbol{\Omega}$ is accompanied by the following processes connected with “free” electrons constituting ferromagnet (see Figure 6).

1) According to the Barnett effect [16], the magnetization of ferromagnet takes place, that is, spin magnetic moment $\boldsymbol{\mu}_q$ of “free” electrons of ferromagnet is oriented as $\boldsymbol{\mu}_q \uparrow\uparrow \boldsymbol{\Omega}$.

2) Taking into account that electron spin $\mathbf{S}_q \uparrow\downarrow \boldsymbol{\mu}_q$ [17], the following is true

$$\boldsymbol{\Omega} \uparrow\downarrow \mathbf{S}_q. \quad (19)$$

3) According to Eqs (11) and (19), frequency of precession of virtual photon spin (created by “free” electron) $\boldsymbol{\omega}_{v1}$ changes to the frequency of $\boldsymbol{\omega}_{v2}$ oriented as

$$\boldsymbol{\Omega} \uparrow\downarrow \boldsymbol{\omega}_{v2}. \quad (20)$$

4) According to Eqs (9)-(10) and (20), the following Condition is true

$$\boldsymbol{\Omega} \uparrow\uparrow \mathbf{u}, \quad (21)$$

where $\mathbf{u}$ is the velocity of “free” electron in the rotating ferromagnet.

Thus, as a result of rotation of ferromagnet, the initial frequency $\boldsymbol{\omega}_{v1}$ of precession of spin of virtual photon created by “free” electron and its velocity $\boldsymbol{\upsilon}$ change to, respectively, the frequency of precession $\boldsymbol{\omega}_{v2}$ and velocity $\mathbf{u}$. The change in the velocity of “free” electron means that the changes in projections of the electron spin $\mathbf{S}_v$ on directions $\boldsymbol{\upsilon}$ and $\mathbf{u}$ arise. That is, according to Eqs (10) and (13), the following equalities take place: $\left|\Delta\left(\mathbf{S}_v\right)_{\mathbf{u}}\right| = S_v\sqrt{1-u^2/c^2}$ and $\left|\Delta\left(\mathbf{S}_v\right)_{\boldsymbol{\upsilon}}\right| = S_v\sqrt{1-\boldsymbol{\upsilon}^2/c^2}$. The emergence of inequalities $\Delta\left(\mathbf{S}_v\right)_{\boldsymbol{\upsilon}} \neq 0$ and $\Delta\left(\mathbf{S}_v\right)_{\mathbf{u}} \neq 0$ means the emergence, respectively, of force $\mathbf{F}_{\boldsymbol{\upsilon}}$ influencing the velocity $\boldsymbol{\upsilon}$ and of force $\mathbf{F}_{\mathbf{u}}$ influencing the velocity $\mathbf{u}$. According to Eq. (14)

$$\mathbf{F}_{\boldsymbol{\upsilon}} = -\boldsymbol{\upsilon}\gamma_s\left|\eta S_v/\left(c^2\sqrt{1-\upsilon^2/c^2}\right)\right|\partial\boldsymbol{\upsilon}/\partial t, \quad (22)$$

$$\mathbf{F}_{\mathbf{u}} = -\mathbf{u}\gamma_s\left|\eta S_v/\left(c^2\sqrt{1-u^2/c^2}\right)\right|\partial u/\partial t. \quad (23)$$

The resulting force influencing “free” electron in rotating ferromagnet is determined as

$$\mathbf{F}_{\boldsymbol{\Omega}} = \mathbf{F}_{\boldsymbol{\upsilon}} + \mathbf{F}_{\mathbf{u}}. \quad (24)$$

Figure 6 shows the characteristics of virtual photon created by “free” electron before the rotation of the ferromagnet ($\boldsymbol{\omega}_{v1}$ and $\boldsymbol{\upsilon}$) and during the rotation ($\boldsymbol{\omega}_{v2}$ and $\mathbf{u}$); β is a deflection angle; $\boldsymbol{\mu}_q$ is spin magnetic dipole moment of electron; $\mathbf{S}_q$ is spin of “free” electron; $\mathbf{F}_{\boldsymbol{\upsilon}}$ and $\mathbf{F}_{\mathbf{u}}$ are forces acting on “free” electron (velocities $\boldsymbol{\upsilon}$ and $\mathbf{u}$); $\mathbf{F}_{\boldsymbol{\Omega}}$ is a resulting force acting on “free” electron of ferromagnet.

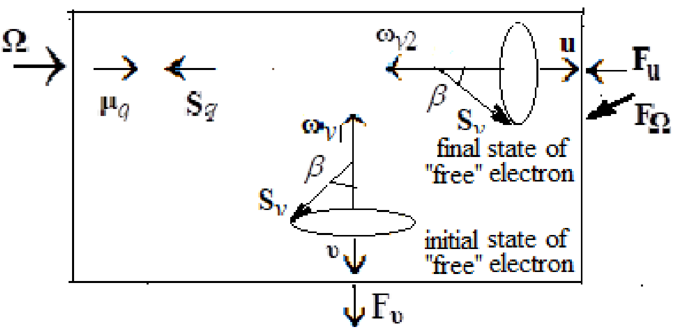

Figure 6: Schematic images of virtual photon created by a "free" electron in initial and final states. $\mathbf{\Omega}$ is the angular velocity of ferromagnet's rotation; $\boldsymbol{\omega}_{v1}$ is the initial value of precession frequency of spin $\mathbf{S}_v$; $\boldsymbol{\omega}_{v2}$ is the value of precession frequency of spin $\mathbf{S}_v$ during the rotation of ferromagnet; β is a deflection angle; $\boldsymbol{\mu}_q$ is spin magnetic dipole moment of electron; $\mathbf{S}_q$ is spin of electron; $\boldsymbol{\upsilon}$ and $\mathbf{u}$ are, respectively, initial and final values of "free" electron velocity; $\mathbf{F_u}$ and $\mathbf{F_\upsilon}$ are forces acting on "free" electron; $\mathbf{F_\Omega}$ is a resulting force acting on "free" electron of ferromagnet.

Eq. (24) determines the force acting on one "free" electron constituting the rotating ferromagnet.

Let us analyze the total force $\mathbf{F}_{\mathbf{\Omega}t}$ acting on rotating ferromagnet.

The force is equal to the sum of forces acting on all "free" electrons constituting the ferromagnet. According to Eqs (22)-(24), the force $\mathbf{F}_{\mathbf{\Omega}t}$ can be represented as

$$\mathbf{F}_{\mathbf{\Omega}t} = \sum_{i=1,..,N} (\mathbf{F_\upsilon})_i + \sum_{i=1,..,N} (\mathbf{F_u})_i \,, \qquad (25)$$

where N is the number of "free" electrons in ferromagnet; the force $(\mathbf{F_\upsilon})_i$ is determined by Eq. (22); the force $(\mathbf{F_u})_i$ is determined by Eq. (23). According to Eq. (22), the value of $\sum_{i=1,..,N} (\mathbf{F_\upsilon})_i$ is determined by mutual orientation of velocities of "free" electrons before the rotation of ferromagnet (velocity $\boldsymbol{\upsilon}$). If all orientations of these velocities are equally likely, then the following may be assumed

$$\sum_{i=1,..,N} (\mathbf{F_\upsilon})_i \approx 0 \,. \qquad (26)$$

At the same time, as at the rotation of ferromagnet the force $\mathbf{F_u}$ of every "free" electron, according to Eq. (21), is directed opposite to $\mathbf{\Omega}$, then

$$\sum_{i=1,..,N} (\mathbf{F_u})_i \approx N\mathbf{F_u} \,. \qquad (27)$$

Using Eqs (26) and (27) in Eq. (25) we obtain: $\mathbf{F}_{\mathbf{\Omega}t} = N\mathbf{F_u}$; then from Eqs (21), (23) and (27) it follows that

$$\mathbf{F}_{\mathbf{\Omega}t} \uparrow\downarrow \mathbf{\Omega} \,. \qquad (28)$$

Let us consider some examples.

4.2. The Examples of Forward Motion and Change in the Weight of Rotating Ferromagnet

Let us consider two cases

1) The angle velocity $\mathbf{\Omega}$ of rotating ferromagnet is directed parallel to the Earth's surface (Figure 7)).

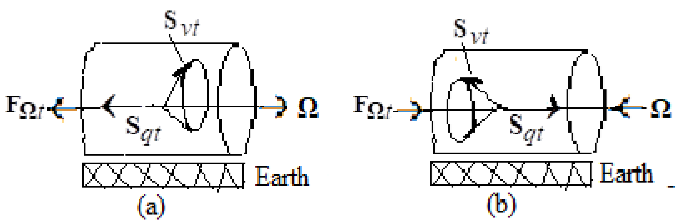

Figure 7: The schematic images of characteristics of rotating ferromagnets. Variant (a) - the forward motions to the left. Variant (b) - the forward motions to the right. $\mathbf{S}_{qt}$ is the total spin of "free" electrons creating virtual photons; $\mathbf{S}_{vt}$ the total spin of virtual photons; $\mathbf{\Omega}$ are the angular velocities of rotation; $\mathbf{F}_{\mathbf{\Omega}t}$ are the forces acting on moving ferromagnets.

In the considered examples the forces $\mathbf{F}_{\mathbf{\Omega}t}$ cause the forward motion of ferromagnets. The similar setup was demonstrated in 1930 under name "Pushcart of Tolchin" [18] and then in 2004 by G. Shipov [19].

2) The angular velocity $\mathbf{\Omega}$ of rotating ferromagnet is directed perpendicular to the Earth (Figure 8).

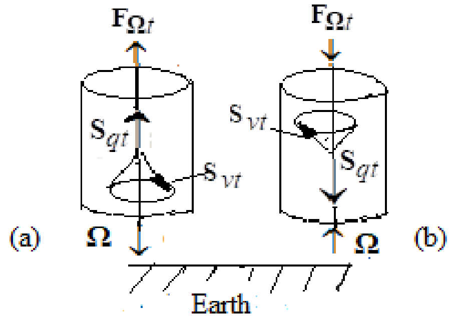

Figure 8: The schematic images of characteristics of rotating ferromagnets. Variant (a) - the ferromagnet with right rotation. Variant (b) - the ferromagnet with left rotation. $\mathbf{S}_{qt}$ is the total spin of quantum objects creating virtual photons; $\mathbf{S}_{vt}$ is the total spin of virtual photons; $\mathbf{\Omega}$ are the angular velocities of rotation; $\mathbf{F}_{\mathbf{\Omega}t}$ is force acting on rotating ferromagnets.

Thus, the right rotation of ferromagnet results in a decrease in its weight as force $\mathbf{F}_{\mathbf{\Omega}t}$ is directed opposite to the vector of gravitation; the left rotation of ferromagnet results in an increase in its weight as force $\mathbf{F}_{\mathbf{\Omega}t}$ is aligned with the vector of gravitation The theoretical conclusion was supported by many experiments. In 1989 H. Hayasaka and S. Takeuchi observed a decrease in the weight of the gyroscope at its right-hand rotation around the vertical axis relative to the Earth [20]; the phenomenon was not observed in the left-hand rotation. In 1999-2000, experiments with rotating magnets were performed by V. Godin and S. Roshchin [21]. In these experiments at a definite speed of rotation, the effect of the changes in the weight was observed: The effect was reversible relative to the direction of the rotor rotation (increase in the left rotation and decrease in the right rotation) under the complete symmetry of setup. Similar experiments were performed as well by V.N. Zatelepin and D.S. Baranov [22].

Notes

Note 1: Let us consider the case where a rotating body is not a ferromagnet and contains "free" positively charged particles (positrons, protons). Then, according to Eqs (9)-(10) and (20), the following is valid: $\mathbf{\Omega} \uparrow\downarrow \mathbf{u}$. Thus, in this case the total force $\mathbf{F}_{\mathbf{\Omega}t}$ acting on a rotating body, with taking into account Eqs (23) and (25)-(27), is related to angular velocity of rotation $\mathbf{\Omega}$ as $\mathbf{F}_{\mathbf{\Omega}t} \uparrow\uparrow \mathbf{\Omega}$. In the general case, if a rotating body can contain "free" quantum objects of any sign, then, with taking into account Eq. (28), the following holds: $\mathbf{F}_{\mathbf{\Omega}t} \uparrow\uparrow \eta\mathbf{\Omega}$.

Note 2: The change in the spin projection on some directions can be performed not only by the Barnett effect but by using a rotating magnetic field as well**.** The similar field was used in experiments by J. Searl demonstrating the change in the setup weight [23].

5. The Recovery of Initial State of Experimental Setup

At using the expressions determining the value of $\Delta\left(\mathbf{S}_v\right)_{\mathbf{u}}$ (Eqs (4) and (16)) and expressions determining the value of $\partial\left|\left(\mathbf{S}_v\right)_{\mathbf{u}}\right|/\partial t$ (Eqs (6), (14)-(15) and (22)-(23)) it is necessary to take into account that speed u of quantum object should be in the range $0 \le u < c$, and deflection angle β of precessing spin $\mathbf{S}_v$ of virtual photon should be in the range $0 \le \beta < \pi/2$. Consequently, the long-lasting experiments with changing the weight and with forward motion of rotating bodies, with rotation of accelerated moving bodies and with action of the force of inertia in these bodies should contain periods of "recovery" of values of u and β. That is, "working" periods in the experiments should alternate with "recovery" periods (see Figure 9).

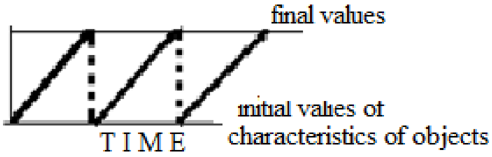

Figure 9: The periods of body testing: and are designations of, respectively, "working" and "recovery" periods.

The theoretical conclusion is in accordance with results of experiments. For example, in experiments by Tolchin, the motion of rotating body is carried out in jerks. In this case, the two periods are produced in the following way: moving weights have been installed on a frame, and these weights moved faster in one direction than in the other (for the details of the mechanism, see [18]).

The "recovery" periods are observed in experiments by V. N. Zatelepin and D.S. Baranov with a change in weight of rotating bodies: the "working" periods of decrease or increase of weight of bodies are replaced by periods of "recovery" of initial characteristics (see Figure 10) [22].

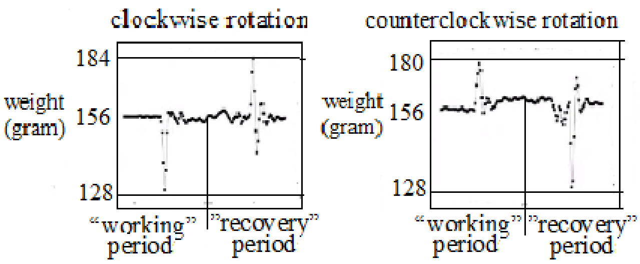

Figure 10: Indications of weight during rotations of experimental setup. The alternation of "working" and of "recovery" periods takes place.

6. Discussion

According to Feynman hypothesis [2], the size of virtual photon is equal to wavelength $\lambda_q = \hbar / (m_q u)$ [17] of the quantum object (with mass m_q) creating the virtual photon. Let us determine the specific force (the force per a length unit) of inertia $(\mathbf{F_u})_s = \mathbf{F_u} / \lambda_q$ assuming in Eq. (6) the $\gamma_s = k / \lambda_q = k m_q u / \hbar$ where k>0 is a factor of proportionality. In this case we obtain

$$(F_{\mathbf{u}})_s = k \left| \frac{u^2}{c^2} \frac{m_q}{\sqrt{1 - u^2/c^2}} \frac{\partial u}{\partial t} \right|. \quad (29)$$

The expression $\frac{m_q}{\sqrt{1-u^2/c^2}} \frac{\partial u}{\partial t}$ in Eq. (29) is a formula for Newton's second law (**F**=*m***a**) in which mass is presented in a relativistic form.

7. Conclusion

Newton's first law (law of inertia) is a manifestation of the law of conservation of angular momentum in the physical vacuum. The force of inertia arises in a body as a result of a change in angular momentum of the body. The change in the angular momentum can emerge at a change in characteristics of spins of virtual photons created by quantum objects constituting the body.

Due to the law of conservation of angular momentum a change in angular momentum results in emergence of processes compensating this change. These compensating processes can be the rotation of object creating the virtual photon or emergence of force of inertia influencing the velocity of this object. The following phenomena are explained by the action of force of inertia.

- The action of the force of inertia on the accelerated moving bodies.
- The rotation of accelerated moving bodies.
- The forward motion (without use of external forces) of a rotating ferromagnets.
- The changes in the weight of a rotating ferromagnets.

These are the processes that are observed in experiments.

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