Reactionless motion explained by the Laws of the Nonlinear Dynamics leading to a new method to explain and calculate the gyroscopic torque and its possible relation to the spin of electron

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Abstract: - On one hand the extant mechanics is based on the understanding that the six degrees of freedom are mutually isolated i.e. momentums and angular momentums can not “jump” from one to another degree of freedom. This is a natural consequence of the Newtonian Laws of Dynamics. But the natural example of gyroscope demonstrates that if a body rotates about axis X and turns about Y, a gyroscopic torque generates about Z in fact shows that under some circumstances the degrees of freedom can be connected in a system. The accepted explanation of the phenomenon by means of the method of the vector multiplication in criticized because in fact it just models the phenomenon. The Author’s experience shows that the gyroscopic torque is a result of the inertial effect of the changed direction of the orbiting masses in the plane of turning. We can determine the inertial effect of the changed direction using the Newtonian Laws of Dynamics. Then we realize that the First Newtonian Law states that speed and direction are equal in rights conserved values but on the other hand the Second and Third Newtonian Laws formulate the inertial effect of the changed speed in the frame of the given direction only. So we need to formulate parallel Laws formulating the inertial effect of the changed direction. Applying these understandings to the gyroscopic torque we formulate a new formula showing that the gyroscopic torque depends on the sine function of the correlation between the angular speeds of turning and rotation. We find that the new formula and the one of the vector multiplication calculate almost equal results if the angular speed of rotation is much bigger then the one of turning. Then we find the condition. Exploring the sine function we find that the body does not generate gyroscopic torque if the angular speed of rotation is 1/2 of the one of the turning. Possibly, it corresponds to the 1/2 spin of electron. The paper is an extended version of the already published [1] one.

Key-Words: - Reactionless motion, Classical mechanics, vector multiplication, gyroscopic torque, spin of electron

1 Introduction

On one hand the existing mechanics is based on the understanding that forces, velocities, momentums acting about different directions interact by the cosine of the angle between them. Therefore perpendicularly acting forces/momentums can not affect each other because cosine of nightly degrees is equal to zero i. e. they are mutually isolated. This corresponds to the well known Galileo’s principle of projections stating that force/momentum acting about given direction affects another one by its projection on the second direction calculated by the magnitude of the force times the cosine of the angle between the directions. We can call this mechanics a Cosine-type Mechanics. The principle is extended on the second main kind of motion. The two main kinds of motion also can not affect each other despite of the degrees of freedom they act about. In fact all of the six degrees of freedom are mutually isolated and there is no correspondence between them. Since the nature of the isolation is an inertial one we say that the degrees of freedom of the given closed system are mutually inertial isolated. If every interaction consists of equal and opposite active-reactive forces/torques is closed in the frame of the given degree of freedom without connection to other ones, every closed system of bodies consists of a group (a set, a collection) of six independent interactions. But despite that the group of six (or less) interactions occupies space we can not talk about a spatial interaction because they are not connected in a system. We talk about a collection (a group, a set) of independent interactions. Hence such closed system is symmetrical one. Such closed system is also a linear one because every interaction operates in the frame of the given line (axis) of the given degree of freedom. It is not surprising that Hamiltonian and Lagrangean mechanics deal also with inertial isolated degrees of freedom i.e. with symmetrical closed systems. Next upgrade like for example Noether's theorems also suppose that the degrees of freedom are inertial isolated and therefore in the symmetrical (homogeneous and isotropic) space operate only symmetrical interactions. It reflects the findings of the Special Theory of Relativity. Hence relativity is also closed in the frame of the given degree of freedom and Galilean and Lorenz transformations understand relativity only about axis X without affect (connection) from/to axes Y and Z. We can summarize that the existing Mechanics is a Cosine Mechanics i.e. a one developed in the respect to the inertial isolation between the degrees of freedom. Therefore in the symmetrical Cosine Mechanics violation of the Conservation Laws is not possible.

On the other hand the example of gyroscope demonstrates connected in system degrees of freedom. If a flywheel (body) rotates about axis X with angular speed ω_r and in the same time turns about Y with angular speed ω_t it generates a gyroscopic torque τ about axis Z, perpendicular to the first two. The rotation and turning interact maximally if they are perpendicular i.e. if the sine function of the angle between them accepts its maximal value. This is the reason we can call the kind of mechanics studding the phenomenon a Sine-type Mechanics. In gyroscope we can define degrees of freedom of rotation and turning about X and Y as an incoming ones unlike the degree of freedom of the generated torque about Z as an outgoing one. Since the three degrees of freedom are connected in a system they form a spatial (3D) interaction. Other systems can form an in-plane (2D) interaction. Such spatial (or in-plane) interaction involving connected in a system incomings and outgoings forces/torques acting about degrees of freedom which should be mutually inertial isolated is an asymmetrical one. In many aspects it is also a nonlinear one.

Therefore it appears that the generated action (the generated torque/angular momentum about Z acting from the flywheel to the fundament) is inertial isolated from its reactions (the reactions are the torques/angular momentums applied by the flywheel to the fundament about X and Y as it is explained in [2], [3] and [4]). Hence if the action is inertial isolated from its reactions it means that it is a reactionless so its reactions are also reactionless. Really to generate a vital reactionless torque we need to do more steps. These steps are explained from practical point of view in details in the souses [2], [3], and [4]. Here we can assume that the theoretical precondition allowing reactionless motion is the possibility to penetrate (violate) the inertial isolation between degrees of freedom. This property/possibility provokes the Author's interest to study all possible ways to connect degrees of freedom in a system. The Author found that the theoretical analysis developed to explain the reactionless motion leads to other developments like new understanding what the Laws of Dynamics are, new method to explain and calculate the gyroscopic torque and its possible relation to the spin of electron so they are the purpose of the paper.

Obviously in the symmetrical space operate symmetrical (obeying the inertial isolation between the degrees of freedom) and asymmetrical (spatial, or in-plane formed by violation the inertial isolation between the degrees of freedom) interactions. The existing Cosine Mechanics deals only with symmetrical interactions and does not take in account the asymmetrical ones. Hence we need to develop another mechanics, the so called Sine-type one able to study the theoretical essence of the phenomenon of violated inertial isolation.

2 Problem Formulation

Beside the few known ways to connect degrees of freedom in a system the one used by gyroscope is the most famous one. It is the most well studied and theoretically explained by the existing (Cosine-type) Mechanics.

2.1 Vector Multiplication

Classical mechanics explains the generated gyroscopic torque and calculates its magnitude by the method of the vector multiplication. The method can be found in every textbook because it is classical. The essence is that vector **c** is equal to vector **a** times vector **b** (**c**=**a** x **b**) and perpendicular to plane of the vectors **a** and **b**. Hence (for example) Feynman explained the vector multiplication in the same chapter 20 (page 20-4) [5], he explained the gyroscope. About vector multiplication, Feynman wrote: "*We have then, in addition to the ordinary scalar product in the theory of vector analysis, a new kind of product, called a vector product.*" And then: "*…the magnitude of* **c** *turns out to be the magnitude* **a** *times the magnitude of* **b** *times the sine of the angle between the two.*" Then, about the direction of the vector product **c** determined by the right-hand rule he wrote: "*…the fact that we say a right-hand screw instead of a left-hand screw is a convention, and is a perpetual reminder that if* **a** *and* **b** *are "honest" vectors in the ordinary sense, the new kind of "vector" which we have created by* **a** *x* **b** *is artificial, a slightly different in its character from* **a** *and* **b**, *because it was made up with a special rule."*

The essence of the gyroscopic effect is that if a flywheel with moment of inertia J rotates with angular speed ω_r about axis X and at the same time an external torque applied about axis Y turns the axis with an angular speed ω_t, the flywheel generates a gyro torque τ (also called a gyro couple) about the third axis Z. Just applying vector multiplication to the phenomenon, we determine that the magnitude of the generated torque τ is equal to the angular momentum of rotation vector multiplied by the angular speed of turning (1).

$$\vec{\tau} = \vec{L}_r \times \vec{\omega}_t = J\vec{\omega}_r \times \vec{\omega}_t \qquad (1)$$

The math shape (2) of the relation (1) determines a linear dependence of the magnitude of the generated torque on the correlation between the angular speeds of turning ω_t and rotation ω_r. E_{kr} is the kinetic energy of rotation.

$$\tau_{vm} = J\omega_r^2 \frac{\omega_t}{\omega_r} = 2E_{kr} \frac{\omega_t}{\omega_r} \qquad (2)$$

2.2 Criticism on the vector multiplication

Vector multiplication calculates magnitude and direction in the same time. Even if mathematically correct, the math multiplication calculates the magnitude of the generated torque with the sine of the angle between the angular speeds of rotation and turning. It appears that both angular speeds or the angular momentum of rotation and the angular speed of turning interact maximally if perpendicular. But what is the reason to multiply mathematically rotations about different degrees of freedom if according to the well-established Classical Mechanics they are mutually isolated? With the Feynman's opinion this is because of the special rules. How these special rules changes fundamental principles? The answer that these are the rules is not a scientific solution because it does not explain the phenomenon. For example, the rule that every body falls down when released does not explain why it falls. Such rules just gloss over the truth.

The other products of vector multiplication are the direction of the axis of the generated torque and the direction of the torque about the axis. It is not clear how physically do we receive them. Here are some points here:

1. We do not have the right to apply the Newtonian Laws of Dynamics because they deal with interactions/motions with components placed in the given direction/degree of freedom. Therefore, vector multiplication fails to correspond to the Newtonian Laws of Dynamics.
2. We cannot apply the vector multiplication to perpendicular linear speeds or linear momentum and linear speed. Hence, vector multiplication fails to correspond to the First main kind of motion.
3. We can decompose math multiplication into math sums (for example 3.4=3+3+3+3=4+4+4) and vice versa, we can compose math multiplication by means of chain of math sums. That is way math multiplication corresponds to the lower (as well as to the upper) rank of math operations. We can not decompose vector multiplication into the lower rank of vector operation (the vector sum). We can not receive a direction perpendicular to the plane of the two addends by composing vector multiplication by means of a chain of vector sums of the two perpendicularly acting incoming angular velocities or angular momentum and angular velocity. Vector multiplication fails to correspond to the lower rank of vector operation.

What is actually vector multiplication? It can not be a special property of matter. With the Feynman's opinion about the special rules it should be some kind of an exception from the common rules. It seems that vector multiplication is nothing else but just a model of some unknown real connections covered by the idea of the special rules, intended to make up for a lack of a real explanation.

On the other hand, mass (the given body) rotates in a plane doing an in-plane motion. Therefore, the orbital displacement, the orbital (linear) inertia, the orbital speed, the momentum, the angular speed, the moment of inertia the angular momentum ... i.e. all of the components of rotation together with the equal and opposite reactions are situated in the plane because the mass exists in the plane physically. If we represent an angular motion or its components as a vector perpendicular to the plane, in fact, we are introducing another model of the reality covered by another special rule i.e. this vector is also an artificial one. Therefore, the given vector is a model. It is a model also because even if it reflects the above cites staff of the orbital motion it does not reflect the inertial effect of the changed orbital direction i.e. it does not reflect the full aspect of the rotation. It appears that the model of vector multiplication deals/developes with previous models. Therefore vector multiplication does not explain the nature of the gyro torque; it just shapes it same like for example the special rule for falling bodies excludes the gravitation like a reason.

3 Problem Solution

The Author's research shows that the gyroscopic torque is result of the inertial effect of the change of the direction of the orbital motion/momentum in the plane of turning. Next the idea is developed in few steps.

3.1 The inertial effect of the changed direction

First let's determine the inertial effect of the changed direction, although the reasoning is not new. Let's have a mass m, Fig.1, moving with constant speed v and radius R along the arc ABC. If in the point A the direction of the orbital velocity is along the tangential line 1-1, respectively in the point C the direction is already along the tangent 2-2. The actual change of the direction is with the angle α between the both lines.

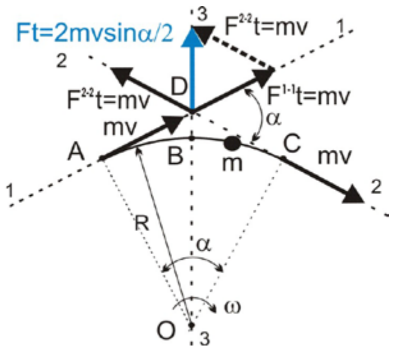

Fig.1. The inertial effect of the changed direction

Let's imagine that instead along the arc, the mass m at the point A moves along the line 1-1. Let's apply on the mass an impulse $F^{1\text{-}1}t=mv$ on the way to make it to stop in the point D. The mass applies on the fundament $F^{1\text{-}1}t=mv$. Then let's apply an impulse $F^{2\text{-}2}t=mv$ to make the mass to move along the line 2-2 in the way to reach the velocity v in the point C. The mass applies on the fundament an equal and opposite reaction. In fact, we replace the motion along the arc ABC with a motion along the lines 1-1 and 2-2 with stop at the point D. The inertial effect of the changed direction is equal to the vector sum of the both impulses applied on the fundament (3).

$$\vec{F}t = \vec{F}^{1-1}t + \vec{F}^{2-2}t \tag{3}$$

$$Ft = 2mv\sin\left(\frac{\alpha}{2}\right) \tag{4}$$

Finally we receive the relation (4). The inertial effect of the changed direction is impulse (4) acting on the point B along the line B-D i.e. perpendicular to the tangent at the convexity of the arc. The formula in not new, for example it is used to calculate the Rutherford Backscattering [6] (see relations (2) and (3) from [6]). On the other hand, for very small time Δt and angle $\Delta\alpha$ sine of small angle is equal the angle ($\sin(\Delta\alpha/2)=\Delta\alpha/2$). We can record the equation as $F=mv\Delta\alpha/\Delta t$. Then if we replace $v=\omega R$ and $\omega=\Delta\alpha/\Delta t$ the relation (4) transforms to the well known formula for the centrifugal force $F_c=mR\omega^2$. Hence, the formula for the centrifugal force can be takes as a private case of the relation (4).

3.2 The Laws of the Nonlinear Dynamics

We look for a connection between the above determined inertial potential of the changed direction and the well established theory trying to avoid the deal with the special rules and the slightly different artificial vectors.

The existing Classical Mechanics (with the exception of the special rules of the vector multiplication) is based on the Newtonian Laws of Dynamics. The Third Newtonian Law states that every force causes equal and opposite reaction. The Second Law determines that the magnitude of the force acting on given body is equal to the mass of the body times its acceleration. We can assume that the equal and opposite forces and the acting force and the acceleration are aligned i.e. the both laws determine that all of the possible changes happen in the frame of the given direction/degree of freedom and nothing can escape out i.e. the directions (so the degrees of freedom) are inertial isolated. The first Newtonian Law states that: "*Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it.*" The division "or" is related to relativity and separates two alternatives: the "*state of rest*" and the "*uniform motion in a straight line*". The alternative "*uniform motion in a straight line*" consists of two conditions: "*uniform motion*" that is to say a motion with constant speed and "*in a straight line*" that is to say the motion is along a straight line. Since every straight line supposes two directions (a "forward" and a "backward" ones) to avoid confusion it is more appropriate to talk about direction instead of straight line. So it means that the

First Newtonian Law determines two conserved conditions: speed and direction. Consequently, the state of the body can be changed by two ways: by change of the speed in the frame of the conserved direction and by change of the direction in the frame of the conserved speed. The First Newtonian Law determines them as equal in rights conserved inertial potentials. That's way to be changed both of them require *"forces impressed"* and both of them react to the change by another forces equal and opposite to the impressed ones.

The Newtonian Laws of Dynamics have been discussed many times during the passed centuries. The question we ask here is: If the First Newtonian Law determines that the state of the body can be changed by two ways, by change of the speed/momentum in the frame of conserved direction and by change of the direction in the frame of the conserved speed/momentum why the following Second and Third Laws deal with one of them only more specially when the speed/momentum changes in the frame of the constant direction? Why the inertial potential of the changed direction in the frame of the conserved speed represented by the centrifugal force is pointed to be fictive fictitious or pseudo one?

The Author accepts that Mother Nature does not play games with fictive forces. We must adapt our understandings to the reality instead of adapting the reality to our understandings by presenting the force of the changed direction as a fictive one and creating replacing models like the one of the vector multiplication.

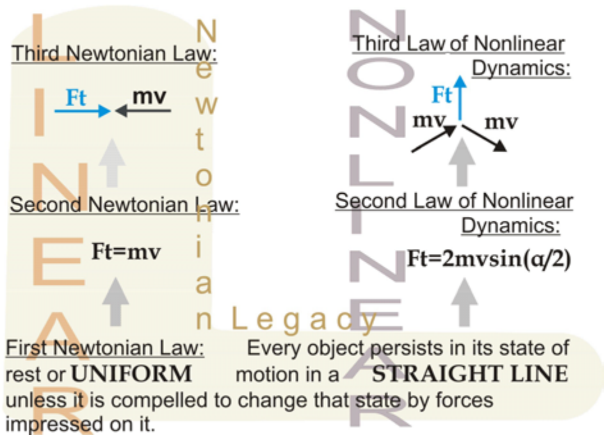

Fig.2. The Laws of the Linear and Nonlinear Dynamics

According to the above reasoning and following the Newtonian formalism the Author assumes that the relation (4) determining the inertial potential (impulse) of the changed direction in the frame of the constant speed can be taken as the Second Law of the Nonlinear Dynamics (Fig.2). The dynamic is called nonlinear because it deals with the inertial potential of the changed direction. The Third Law of the Nonlinear Dynamics can be formulated for example that: "The impulse of the changed direction in the frame of the constant momentum acts perpendicularly the tangent at the point of the releasing" (the point B from Fig. 1).

The math relation of the both Second Laws are represented by their impulses shapes (instead in the shapes of forces) because these shapes are more appropriate if we calculate cycles.

In the Second Newtonian Law the impulse Ft is equal the mass times the change of the speed i.e. the argument is the change of the speed/momentum in the frame of the given direction. So it is correctly to record it as Ft=mΔv. In the Second Law of the Nonlinear Dynamics the speed/momentum is constant. The argument is the rate of change of the direction in the frame of the given momentum represented by the angle of deflection. Hence even if the Second Law of the Nonlinear Dynamics is determined by the Second Newtonian Law (Fig.1.) they formulate inertial effects caused by two different physical/natural arguments. On the other side the relation from Fig.1 demonstrates correspondence. Both impulses are comparable to each other but in the same time since the different nature of their creation they are different.

3.3 Example for together work of the Laws of the Linear and Nonlinear Dynamics

The together work of the Second Laws of the Linear and Nonlinear Dynamics can be demonstrated by a simple example from Fig.3. Let us have a mass m rotating around the center O with an orbital speed v. The mass decelerates with Δv in point A and then accelerates in the opposite point B with the same Δv. Hence according to the Second Law of the Linear Dynamic the mass releases at these points an impilses Ft=mΔv. The nonlinear inertial effect of the changed direction of the orbital momentum m(v-Δv) from A to B and mv from B to A is calculated according to the Second Law of the Nonlinear Dinamics. The linear and nonlinear impulses act along the axis X.

We calculate the balance of the impulses for one cycle (5).

$$2mv\sin\frac{\pi}{2} = 2m(v-\Delta v)\sin\frac{\pi}{2} + m\Delta v + m\Delta v \quad (5)$$

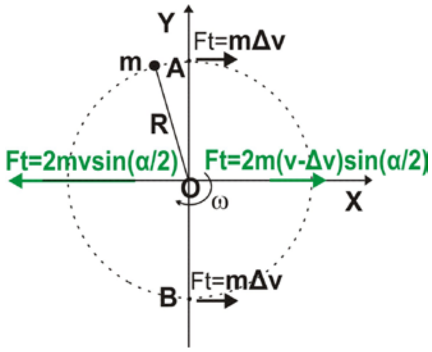

Fig.3. Together work of the Second Laws of the Linear and Nonlinear Dynamics

By the way the example presents the most speculative idea for inertial propulsion generating reactionless thrust by periodically change of the angular speed of unbalanced mass. Many of the so called inertioides use a similar cycles. For example the case is discused from the point of view of the well wstablished Cosine-type Mechanics in [7]. The satisfied equation (5) shows that generation of net reactionless force is not possible in the frame of the given (one, single) degree of freedom even if both of the inertial potentials (the ones of the changed speed and changed direction) are involved. Reactionless effect can be received only if the inertial isolation between degrees of freedom is broken.

3.4 The new method to explain and calculate the gyroscopic torque

Gyroscope demonstrates three connected in system degrees of freedom. The vector multiplication does not discover the exact inertial mechanisms of the connection through the inertial isolation. It just models the connection. The Author's understanding is that the gyroscopic torque around Z is result of the inertial effect of the changed direction of the orbiting around X mass in the plane of turning perpendicular to Y. So let's apply the Second Law of the Nonlinear Dynamics (4) determining the inertial effect of the changed direction to the case of gyroscope Fig.4.

Imagine that a single mass m_1 or an elementary mass $m_{1,}$ belonging to a massive body rotates with constant angular velocity ω_r around the axis X, perpendicular to the page, Fig. 4a. For every π period of rotation, the mass leaves point A and arrives at point C describing the arc ABC in the plane of rotation. Respectively, the opposite mass m_2 describes the arc CDA. Therefore, the masses move along a straight line ABC (CDA) in the plane of page perpendicular to the axis Y, Fig. 4b. But if at the same time the axis of rotation X turns with constant angular velocity ω_t around Y Fig. 4b, the masses arrive at points C_1 or A_1 in the space instead of at points C or A, describing a 3D arcs. That is to say, these masses describe the in-plane arcs ABC_1 and CDA_1 in the plane perpendicular to the axis Y. During the next π period of rotation, the mass m_1 describes the arc C_1DA_2 while m_2 describes A_1BC_2 and so on and so forth. Every elementary mass, belonging to the rotating body, describes arcs in the plane perpendicular to the axis of turning Y. Therefore, an inertial impulse of the changed orbital direction in the plane of turning releases. According to the Laws of the Nonlinear Dynamics, we can accept that it releases in the points B and D perpendicular to the plane of rotation when the given mass is at these points of space i.e. at the convexity of the arc. Since the convexity of A_nBC_{n+1} arc is oppositely directed to the convexity of the C_nDA_{n+1} one, the directions of the impulses acting on points B and D are oppositely directed. Since they act at the opposite sides of axis Z relative Y they create the same directed angular impulses around Z, Fig.4a.

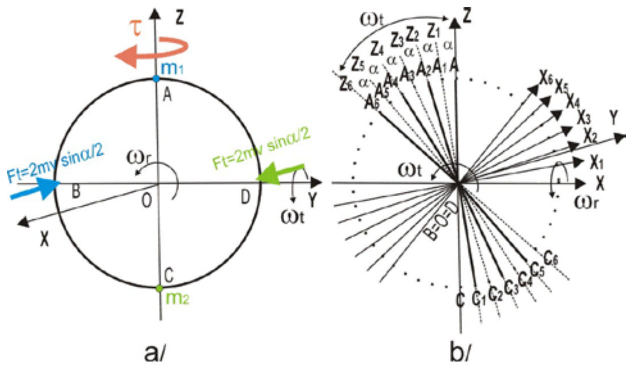

Fig.4. a/ two masses m_1 and m_2 in the plane of rotation, b/ a single mass m_1 in the plane of turning

This explanation refers to the Feynman's understanding from Fig. 20-4 of [5], where the "before" position of the mass, m_1 is at point A_n, the "now" one it is at B and the "after" one it is at C_{n+1}. The "before" position of the mass m_2 is at point C_n, the "now" is at D and the "after" one is at A_{n+1}.

As a matter of fact, the Author introduced the idea about the role of the inertial effect of the 3D arcs described by the orbiting mass for the first time in the PCT/BG2007/000022 predecessor of the patent application [4] in 2006. Then he explained the idea in [2] and [3] with the help of the maximal magnitude line (this is the line BOD from Fig. 4) and zero magnitude & inversion line (A_nOC_n)

perpendicular to the previous one.

We can assume that the impulse Ft (4) of the changed direction of the given mass releases at the points B and D periodically, in portions (stages) for every π (or a half) revolution around X from A_n to C_{n+1} and from C_n to A_{n+1}. We call this phenomenon a π-quantization or a half-quantization.

Using this ratiocination let's calculate the gyroscopic torque τ_{new} generated about axis Z by the impulses (4) of the changed direction of a single mass m_1 in the plane of turning Fig.4b. If for one π-quantum (a half revolution about axis X) the mass m_1 describes arc A_nBC_{n+1}, for the next π-quantum it describes the arc $C_{n+1}DA_{n+2}$. The mass describes a given number of arcs ABC_1, C_1DA_2, A_2BC_3, C_3DA_4 … per second. For every arc described the mass releases an impulse (4) at points B or D perpendicular to the plane of rotation when the mass is at that points. The number of the π–quantum per second N_π is equal to the number of the described arcs per second, which is equal to the number of the impulses (4) per second. We calculate N_π dividing the angular speed of rotation ω_r to π (6). Dividing the angular speed of turning ω_t to the number of the π-quantum per second N_π we receive the angle of deflection α of the orbital speed at the points B and D in the plane of turning for every π–quantum (7). The relation (8) shows the magnitude of one impulse of the changed direction generated by one elementary mass for one π-quantum. Multiplying both sides by the radius R (the distance O-B or O-D) we determine the magnitude of one angular impulse (9). To determine the magnitude of the torque τ_{new} generated for one second we multiply both sides by the number of the π-quantum per second N_π (10).

$$N_\pi = \frac{\omega_r}{\pi} \tag{6}$$

$$\alpha = \frac{\omega_t}{N_\pi} = \frac{\pi\omega_t}{\omega_r} \tag{7}$$

$$Ft = 2mv \sin\frac{\pi\omega_t}{2\omega_r} \tag{8}$$

$$FtR = 2mvR \sin\frac{\pi\omega_t}{2\omega_r} \tag{9}$$

$$\tau_{new} = FtRN_\pi = \frac{2}{\pi} mvR\omega_r \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r} \tag{10}$$

We replace the orbital speed of the elementary mass v by the angular speed of rotation times the radius of rotation $v=\omega_r R$ (11). Then replacing the moment of inertia of a point (elementary) mass m at a distance R by $J=mR^2$ we get an equation (12). The equation (13) expresses the role of the kinetic energy of the rotating E_{kr}. We assume that using the new method of analysis based on the Laws of the Nonlinear Dynamics, we determine the magnitude, the axis and the direction about the axis of the generated gyro torque τ_{new} without the help of the vector multiplication.

$$\tau_{new} = \frac{2}{\pi} mR^2\omega_r^2 \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r} \tag{11}$$

$$\tau_{new} = \frac{2}{\pi} J\omega_r^2 \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r} \tag{12}$$

$$\tau_{new} = \frac{4}{\pi} E_{kr} \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r} \tag{13}$$

3.5 First Check

We have on hand two rival formulas, the one of the vector multiplication (2) and the new one (12) or/and (13). Let us try to find how they work for different correlations between the angular speeds of turning and rotation given in the first column at the Table 1.

$\frac{\omega_t}{\omega_r}$	τ_{vm}	τ_{new}	$d_r = \frac{\tau_{vm}-\tau_{new}}{\tau_{vm}} 100,\%$
$\frac{1}{10000}$	10000	9999.99995	0.00000047
$\frac{1}{1000}$	1000	999.99959	0.0000412
$\frac{1}{100}$	100	99.9959	0.0041
$\frac{1}{10}$	10	9.959	0.41
$\frac{1}{1}$	1	0.637	36.34

Table 1. It compares the results calculated by the τ_{vm} and τ_{new} formulas for different correlations into angular speeds of rotation and turning

We take that the moment of inertia of the given body is equal to one (J=1). The units of ω_r, ω_t, τ_{vm}

and τ_{new} are not given because the final purpose is the calculation of the percentage of relative difference d_r, displayed in the last column. Comparing the results, we find that both formulas calculate results with negligibly small difference, if the speed of rotation is much greater than the one of turning.

3.6 Second Check

Let us try to find the math condition under which both formulas (2) and (12) calculate equal results. Equating both formulas, we receive (14) and (15). Then multiplying both sides of (15) by $(\pi/2\omega_r^2)$ we receive (16). Replacing the connection for the angle of deflection α (7) we receive (17).

$$\tau_{vm} = \tau_{new} \qquad (14)$$

$$J\omega_r^2 \frac{\omega_t}{\omega_r} = \frac{2}{\pi} J\omega_r^2 \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r}; \left(\frac{\pi}{2\omega_r^2}\right) \qquad (15)$$

$$\frac{\pi}{2}\frac{\omega_t}{\omega_r} = \sin\frac{\pi}{2}\frac{\omega_t}{\omega_r} \qquad (16)$$

$$\frac{\alpha}{2} = \sin\frac{\alpha}{2} \qquad (17)$$

The trigonometric condition (17) shows that both methods calculate equal results if the sine of half of the angle of deflection from Fig.4 b is equal to the half of the angle. That is to say, the both methods calculate equal results if the angle of deflection of the orbital momentum in the plane perpendicular to the axis of turning for every π-quantum of the rotation is small enough to satisfy condition (17). The equation (7) shows that the condition (17) is satisfied if the angular speed of rotation is much greater than the one of turning, $\omega_r >> \omega_t$, respectively if $\omega_t << \omega_r$. We call it a Classical Gyroscopic condition because it determines the joint range of the both methods. But what if the angular speed of rotation is just greater than the one of turning ($\omega_r > \omega_t$)? What if both angular speeds are equal ($\omega_r = \omega_t$)? Or what if the angular speed of rotation is lower than the one of turning ($\omega_r < \omega_t$)? These cases stay out of the joint range. Which one of the both formulas calculates correct result out the joint range? We assume that the new formula (12) and (13) calculates an always-correct result independently, if the angle is small enough to satisfy condition (17), not small enough, big or very big because the sine function calculates correct result in any case. It appears that the math equation (2) of the vector multiplication reflects only one private case of the correlation between the angular speeds of turning and rotation when ($\omega_r >> \omega_t$). Obviously, the other possible cases stay out of the range of the method of the vector multiplication because if it calculates a correct result only if the Classical Gyro condition (17) is satisfied. Therefore the Classical gyro condition (17) does not show the limit of the gyroscopic properties as a Mother Nature's product. It demonstrates the limit of the properties of the vector multiplication as to explain gyroscope as a mankind's product.

By the way the Classical Gyroscopic condition (17) transforming the new formula for the gyroscopic torque (12) into the private case of the vector multiplication (1) is the same one transforming the Second Law of the Nonlinear Dynamics (4) to the private case of the centrifugal force as explained in the end of the chapter 3.1.

We saw that the inertial isolated degrees of freedom can be connected in a system by the inertial effect of the changed direction determined by the Laws of the Nonlinear Dynamics including the First Newtonian Law. If the Laws of the Liner Mechanics determine that all of the inertial changes happen only in the frame of the given degree of freedom i.e. all of them are inertial isolated forming this way the existing Cosine-type Mechanics, the second inertial potential determined by the Laws of the Nonlinear Dynamics cans connect (under some conditions) degrees of freedom in a system forming 2D and 3D interactions. The purpose of the Sine-type Mechanics is to study all possible ways to connect degrees of freedom in a system.

4 Expanding the Frontiers

The new method gives a realistic picture of the exact inertial mechanisms of the connection thought the inertial isolation. Now we can explore the gyroscopic properties out of the range of the Classical Gyro condition (17).

We can present the new relation for generated gyro torque (12) as a multiplied constant and factors (arguments). Let us denote a Gyroscopic Constant $K_g=2/\pi$ (18) and then the Gyroscopic Factor G_f (19) as a correlation between the angular speeds of turning and rotation. Then we present the Qualitative Gyroscopic Factor q_{gf} (20) as a sine function of G_f times 1/ K_g. The kinetic energy of rotation E_{kr} plays the role of the Quantitative Gyroscopic Factor Q_{gf} (21). The equation (22) shows that the magnitude of the generated torque is equal to two times the gyroscopic constant K_g times the Quantitative Gyroscopic Factor Q_{gf} times the Qualitative Gyroscopic Factor q_{gf}.

$$K_g = \frac{2}{\pi} \tag{18}$$

$$G_f = \frac{\omega_t}{\omega_r} \tag{19}$$

$$q_{gf} = \sin \frac{1}{K_g} G_f \tag{20}$$

$$Q_{gf} = E_{kr} \tag{21}$$

$$\tau_{new} = 2K_g Q_{gf} q_{gf} \tag{22}$$

Obviously, the behavior of the Qualitative Gyro Factor q_{gf} as a sine function of the correlation between the angular speeds of turning and rotation determines the qualitative behavior of the generated gyroscopic torque. Fig.5 shows the change of the q_{gf} as a sine function of $G_{f.}$ in the range from -4 to 4.

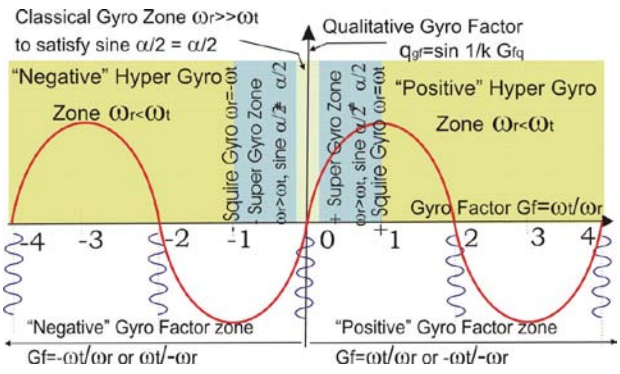

Fig.5. Qualitative gyro factor q_{gf} as a function of Gyro factor G_f

We can see that q_{gf}=0 and therefore the generated gyro torque is equal to zero, if ω_t=0. This is the so-called Central or Classical zero. The right side toward the Central zero is the zone of the positive G_f where the correlation between angular speeds of turning and rotation is positive. The left side is the zone of the negative G_f. The thin strip occupying both sides close to the Central zero is the Classical Gyro zone where the Classical Gyroscopic condition (17) is satisfied. The zone of a Square gyroscope is determined on the condition that the angular speed of turning is equal to the one of rotation i.e. Gf is equal to plus/minus one. A Super gyroscope occupies positive and negative zones (in blue) between a Square and a Classical gyroscope where the correlation between both angular speeds is less than one but not low enough to satisfy the Classical Gyro Condition (17). Obviously, the Hyper gyroscope (in green) responds to the condition G_f>1.

As we can see, the sine function accepts its maximal value of one (q_{gf}=+/-1; where G_f=+/-1) when the angular speed of rotation is equal to the angular speed of turning. This is the so called Square gyroscope. The physical explanation is that for every half revolution about axis X (π-quantum) the plane of rotation completes half a revolution about axis Y, perpendicular to the page, Fig. 4 b. That is to say that every mass m_1 (or m_2) leaving point A_n (or C_n) in the space arrives at the same point A_n (or C_n) completing the arc A_nBA_n (C_nDC_n) with maximum possible angle of deflection equal to π i.e. a closed 3D curvature. Beyond this point of correlation begins a "countdown" where the real angle of deflection decreases. We can note that the Qualitative Gyro Factor is also equal to one if the angular speed of turning is +/-3, +/-5, +/-7… times bigger than the one of rotation i.e. if G_f accepts positive or negative odd whole numbers (integers).

As we have mentioned, every time the sine function crosses the abscissa the generated torque (gyro couples) becomes zero. That is to say, that the gyroscope is stable because it does not lose energy to generate a gyro torque i.e. it is in a potential well. The function accepts zero if G_f=0, +/-2, +/-4,… i.e. if G_f accepts zero and positive or negative even integers. However, there are some differences. If ω_t=0 at the Central (Classical) zero gyroscope conserves the orientation of its plane of rotation in space. This is well-known property used in gyrocompasses. But if $\omega_t=2\omega_r$, $\omega_t=4\omega_r$ and so on, the gyroscope does not generate torque although its plane of rotation turns about the axis of turning. The physical explanation of that phenomenon is that if the angular speed of turning is equal to zero, in the frame of every π-quantum, every elementary mass moves along the line A_nBC_n (or C_nDA_n) in the plane in turning, Fig.4 b. Therefore, the angle of deflection is equal to zero i.e. the generated gyro torque is equal to zero. But if the angular speed of turning is two (four, six…) times greater than the one of rotation for every π-quantum the body completes a whole revolution (or 2, or more) about the axis of turning. It makes so that finally the mass from point A_n arrives at point C_n (from C_n to A_n) the same as when the angular speed of turning is zero i.e. if the angle of deflection is equal to zero. Therefore, at the Hyper zeros, there is no generation of gyroscopic torque about axis Z, i.e. the degrees of freedom of the gyroscope are disconnected (isolated), despite that the body rotates about X and simultaneously turns about Y.

On the other hand, disturbance coming from the outside can generate oscillations (under some conditions) about the "zeros". For example, we know nutation as an oscillation about the Central (Classical) zero. Similarly, oscillations can be provoked around the Hyper zeros. But if an oscillation about the Classical zero is expressed as an oscillation of the plane of rotation, the oscillation about every Hyper zero is expressed as an oscillation of the correlation between the angular speed of turning and rotation. In fact, every diversion of the correlation in "positive" and "negative" direction connects the degrees of freedom "positively" or "negatively".

We need to mention that together with the already mentioned "zeros" there is another one. The generated gyro torque is equal to zero if ω_r=0. More specifically if the change of the G_f is caused by a change of ω_r i.e. ω_t=constant, the kinetic energy of rotation decreases to zero when ω_r decreases to zero. Hence the magnitude of the generated gyro torque is a periodically decreasing to zero function. If the change of the G_f is caused by a change of ω_t i.e. ω_r=constant. the kinetic energy of rotation is also a constant. Therefore the change of the magnitude of the generated gyro torque follows the sine wave from Fig.5. If the change of G_f is caused by a together change of ω_t and ω_r to explore the change of the generated gyro torque we need to know the connecting function $\omega_t=f(\omega_r)$.

5 Possible connection to the spin of electron

The existing Quantum theory as for example introduced in [8] and [9] states that the charged particles, (fermions, leptons including electron...) are with spin 1/2. The uncharged particles (bosons) are with spin 1. Fermions with other spins including 3/2 and 5/2 and bosons with other spins as 0, 2, and 3 are not known to exist, even if theoretically predicted. In 2013, the Higgs boson with spin 0 has been proven to exist. All of this reduces the possible spin numbers to very few: 0, 1/2 and 1.

What is spin? For example, Shankar, [8], ch.14 wrote: *"It follows that electron has "intrinsic" angular momentum not associated with its orbital motion. This angular momentum is called spin, for it was imagined in the early days that if the electron has angular momentum without moving through space, then it must be spinning like a top. We adopt this nomenclature but not the mechanical model that goes with it, for a consistence mechanical model doesn't exist."* Norbuly, [9] ch.10.4 states: *"As nicely explained … this angular momentum is intrinnsic to the electron and does not arise from orbit effects."*

Can we relate the properties of the 1/2 spin to the properties of the Hyper zeros from Fig. 5 and the dependence (12)? If we accept that spin of electron is a physical rotation of the electron about its axis with an angular speed 1/2 of the speed of turning about a perpendicular axis, an electron does not generate gyro torque about the axis perpendicular to the first two. That is to say that an electron acts as a Hyper gyroscope with a Gyroscopic factor G_f=+/-2. This electron exists in the potential wells because the degrees of freedom are disconnected and an electron or actually an electron-nuclei system does not lose kinetic energy. In fact, the spin of an electron e_{spin} is reciprocal to the Gyroscopic factor at the Hyper zeros +2 and -2 (23).

$$e_{spin} = \frac{1}{G_f^{\pm 2}} = \frac{\pm\omega_r}{\pm\omega_t} = \pm\frac{1}{2} \tag{23}$$

Supported by the analysis from the above we return to the original understanding that electron rotates like a top.

5.1 The intrinsic (principle, primary) axis problem

As we accepted, spin expresses a single physical rotation about an axis. On the other hand a gyroscope works if there are two rotations (or rotation and turning according to the Author's terminology) around a perpendicular axes leading to generated torque about the third axis. Every rotation needs an axis to determine it, so an intrinsic spin requires a clearly determined intrinsic axis.

The uncharged particles rotate (spin) about their axis freely. They receive turning about a perpendicular axis causing gyro effects in special cases like for example collusion and diffraction. Unlike them, the charged particles exist normally in a system connected to opposite charged particles because of the attractive forces. They rotate (spin) freely only when due to certain reasons they lose the system. Hence, existing in a system with nuclei, an electron receives a second motion belonging to the system in addition to its intrinsic spin.

On the other hand, if at the +2/-2 Hyper zeros the speed of turning is two times greater than the one of rotation, the kinetic energy of turning is four times greater than that of rotation (for spherical body). Therefore, an electron ~~cans~~ easily switch over the axes of spin and turning. This cannot happen only if an electron's axis of spins is clearly determined by an intrinsic property of the electron.

The abovementioned considerations/requirements can be satisfied if we suppose that the centers of charge and mass of the electron are divided at some distance "p", Fig. 6. The centers of charge and mass of the nuclei are also divided, but since the nuclei of different chemical elements and isotopes consist of different numbers of protons and neutrons, the centers are divided at different distances. Obviously, the intrinsic axis of the electron is the line connecting the electron's centers of mass and charge. The Coulomb's attractive force directs the electron's center of charge to the nuclei's center of charge while the acting on the electron's center of mass centrifugal force directs it oppositely. Therefore, the forces make so that the three centers are normally in line. Since the electron's center of charge is directed to the nuclei, the electron completes one turn about the axis Y perpendicular to the orbital plane every time it completes one revolution around the nuclei.

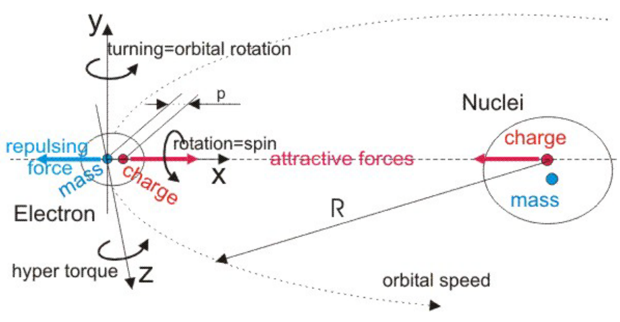

Fig.6. Electron-nuclei system

We can assume that if at the same time the electron completes half a revolution (spin) about its intrinsic axis the electron acts as a Hyper gyroscope in one of the potential wells of the Hyper zeros +2 or -2. The degrees of freedom of the electron-nuclei system are disconnected and therefore it does not lose kinetic energy. The axis of spin cannot be changed by another one because it is irreversibly determined by the intrinsic property of the electron.

Spin here is not measured in radians per second but as a strict one-half correlation (23) between the angular speed of spin about the intrinsic axis directed to the nuclei and the angular speed of turning about an axis perpendicular to the plane of orbiting, equal to the orbital angular speed.

	left	***right***
e spin-up state	$\omega_{spin}=\frac{-\omega_{orbit}}{G_f^{-2}}=+\frac{1}{2}\omega_{orbit}$	$\omega_{spin}=\frac{+\omega_{orbit}}{G_f^{+2}}=+\frac{1}{2}\omega_{orbit}$
e spin-doun state	$\omega_{spin}=\frac{+\omega_{orbit}}{G_f^{-2}}=-\frac{1}{2}\omega_{orbit}$	$\omega_{spin}=\frac{-\omega_{orbit}}{G_f^{+2}}=-\frac{1}{2}\omega_{orbit}$

Table 2. Spin-up and spin-down states like a correlation $\omega_{spin}/\omega_{orbit}$

	left	***right***
e spin-up state	$\frac{1}{G_f^{+2}}=\frac{-\omega_{spin}}{-\omega_{orbit}}=+\frac{1}{2}$	$\frac{1}{G_f^{+2}}=\frac{+\omega_{spin}}{+\omega_{orbit}}=+\frac{1}{2}$
e spin-doun state	$\frac{1}{G_f^{-2}}=\frac{-\omega_{spin}}{+\omega_{orbit}}=-\frac{1}{2}$	$\frac{1}{G_f^{-2}}=\frac{+\omega_{spin}}{-\omega_{orbit}}=-\frac{1}{2}$

Table 3. Spin-up and spin-down states interpreted by the signs of ω_{spin}

If the electrons from the electron couple take "positive" and "negative" Hyper zeros at points +2 and -2 from Fig. 5, we can find that there are four possible combinations between the directions of spin and orbital momentums. According to tradition, we can classify the possible spin-up and spin-down states from Fig. 5 also as left and right ones, Table 2. Table 3 interprets the electron's spin-up and spin-down states with their signs.

5.2 Some basics on the electron's dynamics

If for example, because of some reason, the orbit of the electron reduces by a radius ΔR, it increases its angular speed around the nuclei i.e. the angular speed of turning about axis Y by $\Delta\omega_t$, increasing the orbital momentum/angular momentum. The Gyroscopic factor becomes greater than two (G_f>2). Hence, the spin from Tables 2 and 3 becomes less than one-half of the orbiting. The electron comes out of the given Hyper zero (potential well) and starts to generate Hyper gyro torque according to the relations (12) or (13). If the electron comes out of the +2 Hyper zero it generates a "negative" torque, if it comes out of the -2 Hyper zero it generates a "positive" one. The Hyper torque acts around an axis Z perpendicular to the first two passing through the electron's center of mass, Fig.6. It shifts the electron's center of charge off the line connecting the electron's center of mass and the nuclei's center of charge. It makes the electron's center of charge to do periodical motions dependent on the π-quantization. Probably it leads to emission of electromagnetic wave. On the other hand, every piece of electromagnetic wave "attacking" the electron from outside probably makes its center of charge to do similar periodical motions.

We can call the phenomenon of spin-orbit inertial interaction a spin-orbit inertial coupling. On the other hand, the orbital and spin magnetic moments separately interact with any applied magnetic field (the Zeeman effect) and also with each other i.e. there is a spin-orbit magnetic coupling. In fact, spin and orbit are coupled in two ways - an inertial and an electromagnetic one. All together work in system.

In fact, there are many details. Briefly, we know that every system taken out of its equilibrium tends to recover it. The only way the inertial electron-nuclei system can recover its equilibrium is to bring the correlation between the angular speed of spin and the orbital one to the natural value of one-half. How do the inertial and the electromagnetic couplings work together to recover the equilibrium of the electron-nuclei system? Probably it can provoke a further development.

6 Conclusion

Reactionless motion, connected in a system and isolated degrees of freedom, the Laws of the Newtonian (linear) Mechanics, the Laws of the Nonlinear Dynamics, the formula for the centrifugal force, the new method to calculate the gyroscopic torque, the vector multiplication and the spin of elementary particles are in correspondence. We have the great opportunity to create the most realistic (minimum modeling, maximum reality) model of the atom has been ever created.

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