International Journal of Physical Sciences and Research

GLINT OPEN ACCESS

Volume 1, Issue 1
Research Article

**Date of Submission:** 31 October, 2025
**Date of Acceptance:** 25 November, 2025
**Date of Publication:** 28 November, 2025

# Step Derivative Equations of Inertial Motion in the Classical Mechanics. Conservation Laws

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**Citation:** Djordjev, B. (2025). Step Derivative Equations of Inertial Motion in the Classical Mechanics. Conservation Laws. *Int J Phys Sci Res* .1(1), 01-25.

**Abstract:** In the Newtonian Mechanics, any force exerted by body A on B accelerates B, while the acceleration of B creates an equal and opposite force accelerating A back. We can accelerate one body only at the expense of the opposite acceleration of another body. Therefore, we can only exchange acceleration for acceleration, because force only creates acceleration, and acceleration only creates force. With other words, we can equal mathematically, and respectively exchange physical derivatives of the displacement of two bodies only if they are the same (of the same power). But in Classical Mechanics there are formulas that relate force as a function of the product of two velocities instead of the function of acceleration. For example, these are the formulas for the centrifugal force and the gyroscopic torque. If we substitute the two force expressions into Newton's Third Law, it turns out that we mathematically equate acceleration as function of the product of two velocities. That is, we equate derivatives of the displacement of the two bodies of different degrees (acceleration = function times (speed times speed). We define this dependence as step derivative equation of inertial motion. If this dependence is not a product of mathematical formalism, but is real physical, inertial, it means that we can exchange real acceleration of one body for real speed of the other. The disproportion in the equations of the step derivatives of inertial motion affects the Laws of Conservation of Angular Momentum and Momentum. The development has been confirmed experimentally.

**Keywords:** Newtonian Mechanics, Classical Mechanics, Force, Acceleration, Speed, Conservation Laws

## Introduction.

In 1996 NASA established the Breakthrough Propulsion Physics program. The aim is "… to seek the ultimate breakthroughs in space transportation: propulsion that requires no propellant mass …" This can mean at least two fundamentally different things: propulsion that creates thrust by interacting with external phenomena such as solar wind, gravitational fields, wormholes and others, or propulsion that creates thrust at the expense of the phenomena in the vehicle without using reactive mass [1].

In fact, propellant, as we understand it, is a rocket chemical fuel providing both the reactive mass and the energy for its ejection with acceleration (expelling). Obviously, to get closer to the solution, we need to separate the reactive mass from the energy. This, for example, happens in the ion engine, where the reactive mass and the energy are separated. Then the task looks like this: We need propulsion that consumes energy to create thrust but without using reactive mass. Then one must either create thrust without reaction, or create thrust with reaction but no reactive mass, or thrust with reaction and reactive mass but without expelling. In fact all these are different forms of interpretations of the idea of "Reactive less propulsion".

The hopes of thousands of researches from many generations to achieve such a propellant less (reactive less) propulsive effect are connected, in additional to the mentioned in coupling of gravity and electromagnetism, vacuum fluctuation energy, warp drives and worm-holes, and superluminal quantum effects, are also related to a whole host of other physical phenomena [1]. Over the years, many researchers have tried to bring some order in the chaos of diverse solutions by systematizing and classifying them according to some chosen criterion. Other simply list everything known, pleading for competences, or list the most promising from their point of view. In fact, time has shown that none of these systematizations are complete. Anyway, one example is [2]. In example we pay particular attention to Chapter 7 "Propellant less propulsion" and Chapter 8 "Breakthrough propulsion" [3].

But the Author would suggest a different arrangement and classification of all ideas. If we imagine Physics as a tree, we will find that the overwhelming majority of proposed ideas are from the highest and thinnest branches of the tree. This is understandable, because the higher you go, the more opportunities there are. In addition, they are also less studied, so if you expect a breakthrough, it is logical that it can only be done up there, on the border of the unknown. In contrast, the lower we go, the more everything is known and studied, or as they call it "well established".

There are also those from the middle branches. For example the famous in recent years EM Drive, which relies on the idea that electromagnetic resonance in a copper conical tube, can create unidirectional thrust [4]. Other works rely on Mach's Principle for distant masses [5]. We mention without citing the study of momentum in multidimensional spaces, the idea of antigravity, and others. Now further down, in the field of Classical Mechanics, many ideas related to known inertial phenomena are developed, for example [6,7]. We pay special attention to numerous developments united under the general term "inertoids" [8]. They state that rotation of unbalanced mass with a cyclically variable angular acceleration (sometimes with a variable radius of rotation) can create a unidirectional force, at the expense of unbalanced orbital and centripetal accelerations. In this regard we mention the famous Dean drive, gyroscopic inertial thruster, the works of Laithwaite and Tolchin and many others. Including the experiment with a similar device carried out in space on board the Jubileyni satellite by the Khrunichev Research Center [8].

If we go down, of course we will reach the famous Newton's Laws of Dynamics. And further down we will reach the bottom. There are Galileo's Principles of Relativity and Projections. And if we want to get the seed itself, to the very point of indeterminacy, this, according to the Author, is the Principle of the Projections. Everything in Mechanics and Physics obeys it, even relativity. The exceptional role of the Principle of Projections is that it predetermines the linearity of the whole theory build up.

But in the present work we will not go that low. We will position the present work somewhere below Lagrange, Hamilton, Euler, but above Galileo. This is an area of Physics that has been accepted as a constant for two-three-four centuries. Works such as this one dealing with age-old constants in Physics are produced extremely rarely.

**Newtonian Laws. Equations of the Plane Derivatives of Inertial Motion**

Newtonian and Classical Mechanics study the inertial interaction between bodies. Newtonian Mechanics ranks the forms of motion: relatively stationary, relative displacement for a given time (speed), and change of speed of displacement for a given time (acceleration). The Third Law (1) declares that the active force as cause and the reactive force as effect are of one quality and in equal quantities. The Second Law (2) states that the applied force F accelerates the mass m with an acceleration a. If we substitute (2) on the both sides of (1), we will get (3). We find that the acceleration of one mass is equal to the acceleration of the other mass, inversely proportional to the ration between the masses. If we divide (3) by the time, we will get that the amounts of movement of the two masses are equal (4). If we divide (4) by the time, we will get that the displacement of one mass per unit time is equal to the displacement of the other mass, inversely proportional to the ration between the masses (5).

$$F_{active} = F_{reactive} \quad (1)$$

$$F_a = m_1 a_1; F_r = m_2 a_2 \quad (2)$$

$$m_1 a_1 = m_2 a_2; a_1 = \frac{m_2}{m_1} a_2 \quad (3)$$

$$m_1 v_1 = m_2 v_2; v_1 = \frac{m_2}{m_1} v_2 \quad (4)$$

$$m_1 s_1 = m_2 s_2; s_1 = \frac{m_2}{m_1} s_2 \quad (5)$$

We understand that we always associate forms of motion from the same derivatives of displacement: acceleration of one mass with the acceleration of another, the speed (amount of motion) of one mass to the same quality of the other, the displacement of one, for the displacement of the other. Figure 1 visualizes the plane (of one quality) dependences. Here we call the equations of these connections of equal qualities of the derivatives of the motion "Equations of the plane (equal) derivatives".

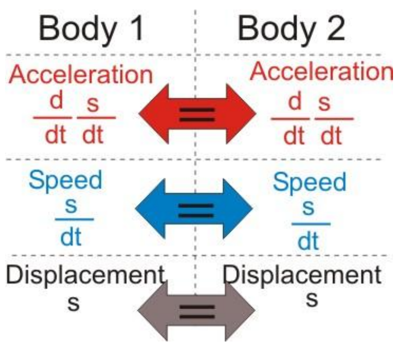


Figure 1. Visualization of the equations of the plane derivatives.

Newtonian Mechanics therefore obliges us to physically exchange only the acceleration of one body for the proportional acceleration of another body; speed for proportional speed; displacement for proportional displacement. Cross derivative equations are not possible. Respectively different derivatives (forms of motion) are not interchangeable! These conditions are an absolute prerequisite to the observance of the Conservation Laws.

**Equations of the Step Derivatives of Inertial Motion**

But in the corners of Classical Mechanics one can find another category of equations that relate different derivatives (qualities) of inertial motion. These are not laws like Newton's, just equations. But apparently they work, and are an indicator of the existence of another reality of inertia.

$$F_c = mv\omega \quad (6)$$

$$F_k = 2mv\omega \quad (7)$$

$$\tau_z = J_x \omega_x \omega_y \quad (8)$$

$$\tau_z = \frac{2}{\pi} J_x \omega_x^2 \sin(\frac{\pi}{2}\frac{\omega_y}{\omega_x}) \quad (9)$$

$$a_1 = \frac{m_2}{m_2} v_2 \omega_2 \quad (10)$$

$$\frac{d\omega_z}{dt} = \frac{J_x}{J_z} \omega_x \omega_y \quad (11)$$

To this category we can include, and not only: the equation of the centrifugal force $F_c$ (6); Coriolis force $F_k$ (7); the vector multiplication equation for the gyroscopic torque (8) and the formula (9) proposed by the Author in [9], actually a substitute for (8).

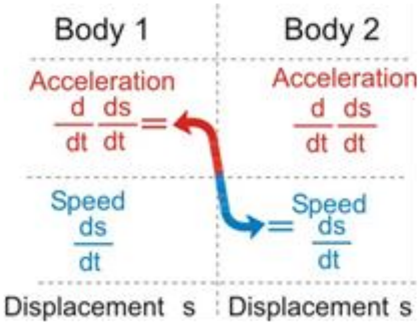


Figure 2. Visualization of the equations of the step derivatives.

The remarkable thing is that all these equations relate a force or torque on one side to a product of two velocities on the other side. If in equation (1) we substitute one force with equality (2) and the other with for example equality (6), we get (10), where the acceleration is a function of the product of two speeds. If we write the equations (1) and (2) for the rotary motion and substitute (2) on one side of (1) and on the other (8), we get (11). We find that the angular acceleration of one body is a function of the product of two speeds of the other body. Figure 2 visualizes the step derivative dependences.

Here we call these equations from (6) to (11), as well as others like them, "Equations of Step Derivatives", because they (unlike equations from (1) to (5)) equalize forms of motion of two bodies from different degrees of derivatives of displacement (Figure 2). The equal sign between both sides of these equations means that we can physically exchange quantities of different qualities (derivatives). Therefore, we can exchange qualities for quantities.

**The collusion between Mathematical formalism and physical phenomena**

In the step derivative equation (6), the dimensionality (dimension) of orbital velocity times angular speed $(v\omega)$ is meter per second squared $(m/s^2)$. The dimension is completely identical to that of linear acceleration $(m/s^2)$. The same dimension is obtained if we substitute the orbital speed with angular $(R\omega^2)$, or angular with orbital $(v^2/R)$. From the point of view of mathematical formalism, is more than justified to assume that the product $(v\omega)$ expresses acceleration, even more so that $(mv\omega)$ creates force. But from the point of view of the derivatives of motion, the product of two speeds (or depending on the shape of the record, the product of one speed with itself) is not acceleration. That is, because Newtonian acceleration is formulated as the rate of change of speed in a given time. Even if the product of two first derivatives of displacement formally has the dimension of acceleration, and they create force, the physical phenomenon of the product of two first derivatives of displacement is not identical physically to the physical phenomenon of one second derivative of displacement. This is probably one of the reasons why Classical Mechanics called the centrifugal force "fictitious".

These considerations apply to all step derivative equations because we see the pattern everywhere: We can find that all formulas of Table 1 from [10], as well formulas (1) to (5), those of Tables 1 and 2 of [11], also in [12] and many others, all repeat the same model: A force or torque is a function of the product of two speeds [10-12]. The persistently repeating pattern of dependences gives us reason to assume that there is a second way to create force: as a function of the product of two speeds, alternative to the first where the force is a function of acceleration.

**The origin of the Step Derivative equations of inertial motion**

It has been the well-established opinion of generations of researchers that violating the Well-Established Natural Laws of Conservation of Angular Momentum and Momentum is impossible because Newton's Laws and specifically the Third Law of equal and opposite forces/torques, forbid it. Therefore, it is extremely surprising to find that the origin of the equations of the step derivatives is already justified by the First Law, and the "violation" is embedded in the whole construction of the three Newton's laws.

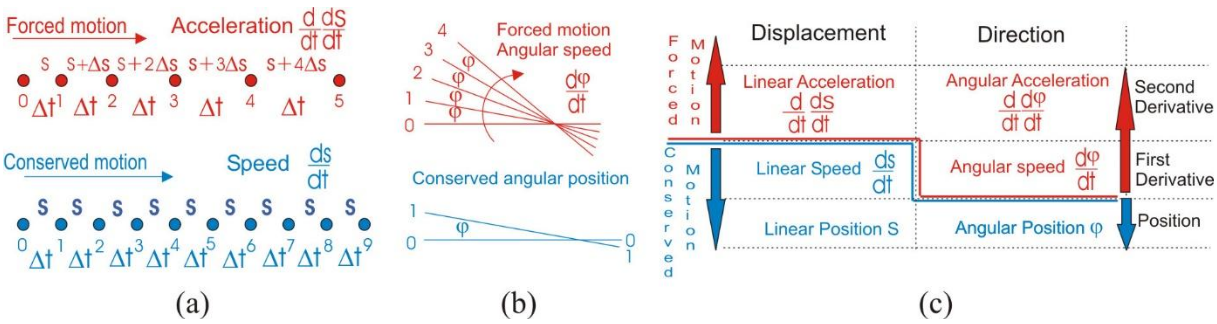


Figure 3. The origin of the step derivative equations of inertial motion. (a) Conserved linear speed and non-conservative linear acceleration. (b) Conserved angular orientation and non-conservative angular speed. (c) Distribution of conserved and forced (non-conservative) forms of motion on the derivative scale.

The First Law declares the speed and direction of a body to be conserved quantities and qualities, that is, self-sustaining without external intervention, see Figure 3 (a) in blue. In contrast, acceleration is non-conservative because it exists only under the action of an external force, see Figure 3 (a) in red. The linear position of the body is also conserved, but we are more interested in the higher derivatives of the motion (speed and acceleration). We note that if the conserved speed is a first derivative with respect to the displacement time, then the conserved direction from Figure 3 (b) does not depend on time. Therefore, if an external force (in red) applied along the direction of the speed (Figure 3 (a)) changes the conserved speed into non-conservative acceleration, (changes the first derivative into a second), then an external force (in red in Figure 3 (b)) applied perpendicular to the speed changes the conserved direction into non-conservative angular speed (first derivative of angular displacement).

It turns out that the same external force when applied along the displacement vector creates acceleration, but when applied perpendicular to the displacement vector creates velocity. Both the acceleration in the first case and the velocity in the second are non-conservable quantities and qualities, because they exist only when the external force acts. Imagine that we then equate the two forces according to the Third Law. It means that the equal and opposite forces have created inertial effects that are equivalent according to the Third Law. This means that the acceleration that one force created is equivalent to the velocity that the other force created. We repeat that this is an equivalence that follows from the equality of the Third Law. But at the same time, according to the Second Law, an acceleration cannot be equivalent to a velocity for at least three reasons: First, because acceleration is the second derivative of displacement and velocity is the first; Second, because velocity is conserved according to the First Law but acceleration is not; and Third, because for the second reason, acceleration is proportional to the applied force because it depends on the force but velocity is not proportional to the applied force since it does not need an applied force to exist. In short, something that is conserved cannot be equivalent to something that is not conserved.

Obviously, this phenomenon, or more precisely the differences between the two phenomena, is the basis of the Step Derivative Equations.

Figure 3 (c) visualizes the step of the motion derivatives of the conserved (in blue) and the forced, i.e. non-conservative forms of motion (in red). Probably no one will deny the complete coincidence of Newton's First Law in Figure 3 (c) and the picture from the Equations of the Step Derivatives from Figure 2. Everything demonstrates that the Step Derivative Equations are neither accidental nor contrary to, or in violation of Newton's Laws of Dynamics.

**Inconsistency in Newton's Laws**

Every body preserves its motion with a constant speed in a straight direction. Both forms of motion, speed and direction, are conserved by inertia. Both forms are changed by an external force. In both, a change of speed and a change of direction, the form of motion-conserving inertia creates a force equal and opposite to the applied force. Direction has an inertial potential to resist change just as velocity has an inertial potential to resist change. The First Law makes no distinction between conservation of speed and conservation of direction. It does not define, for example, that the speed is real and the direction is fictitious.

Are we wrong somewhere? If we are not mistaken, there is a question of fundamental importance: Why then the Second and Third Laws specify the quantitative and qualitative dependences only in the change of speed, and ignore the quantitative and qualitative

dependences in the change of direction? The developments in the Second and Third Laws correspond to only half of the declared qualities in the First Law. Here we call this ignoring "Inconsistency in Newtonian Mechanics".
Probably, the Linear (along geometrical straight line only) nature of the existed Mechanics was established by Galileo with his experiments with uniform accelerating motion, the formula for it and the Principle of Projection. Newton merely continued this trend, although he formulated the inertial potential of conserved direction as equivalent to the potential of conserved speed. It is possible that he took the second potential to be auxiliary, serving the first, the main one, although this is not apparent from the wording. The fathers of Classical Mechanics reinforced the trend by taking the inertial potential of the changed direction as fictitious and introducing the system of two main motions: simple linear and simple rotation as conserving speed forms of motion. This completely ignores the inertial potential of the changed direction as an alternative factor in Mechanics.

Are we forbidden to develop the inertial potential of the changed direction? Who forbade it: us humans on our own, or aliens, or God? Why?

**About Mother Nature's Rules**

Since we are all absolute beginners in the subject of this matter, some initial reflections on the essence will not be superfluous. We found that, on the derivative scale, the step derivative equations equalize forms of motion of different displacement derivatives, Figure 2. Now we are about to find this conflicts with a fundamental priority of Nature, to equate conserved for conserved and non-conservable for non-conservable forms of motion. Nature cannot relate non-conservable for conservable forms of motion because she cannot create something that changes from something that does not change.

This derivation enables us to look at step derivative equations in another way. If for example in (10) the acceleration is a non-conservative form of motion, then the product of the speeds on the right must also be a non-conservative form. The problem is that in Classical Mechanics we know only and only the conserved speeds of the two main motions. In Classical Mechanics, the speeds are distributed along different axes forming a coordinate system of three mutually perpendicular axes for linear motion (speed) and a second coordinate system for rotational motion (angular speed). All six of them are mutually isolates by definition. That is, linear speed of one degree of freedom is isolated from angular speed in another degree of freedom. Therefore, the product of one isolated conserved speed and another isolated conserved speed cannot produce a non-conservative form of motion equivalent to acceleration. Nor does the product of a conserved speed by itself make it non-conservable.

If we believe in the entries of these equations (6) to (11), and in the similar equations from the textbooks, as well as those mentioned from, it will turn out that we obtain non-conservative force (acceleration, energy) from the product of two conserved forms of motion [9-15]. That is, we receive something that has the capacity to change from something that does not change. This is a pure sample of a Perpetual Engine. Now we begin to understand why these forces are declared fictitious. Also we understand why working with these forces is forbidden, just as it is forbidden to deal with it in general.

This means that all physics textbooks around the world, writing down formulas of the type (6) to (8), no more and no less, declare that a force can be obtained from a product of conserved by the formulation of Newton's First Law velocities, and therefore the so-called free force and perpetual motion are possible!? We understand that the way chosen by Classical Mechanics to avoid confusions like this is to call the inertial force "fictitious". In fact, Classical Mechanics gets out of the confusing situation by stating: "Yes, we get force (power) from the product of two conserved (unchangeable) speeds, but we don't advocate a perpetual motion machine because that power is fictitious. Even more so, or precisely because of that, we don't want to deal with this." D'Alembert was the first to declare inertial force fictitious. To be precise, the fictitiousness is two-stage. First stage: The inertial force in both its forms (speed conserving and direction conserving) is fictitious, and therefore excluded from the family of fundamental forces (gravitational, electromagnetic, strong and weak). Second stage: If the inertial force of the changed speed is nevertheless legitimized by Newton's Second Law, which gives it the status of semi-fictitious half-real, not legitimized by any Natural law inertial force of the changed direction is full-scale fictitious (doubly fictitious). In this sense, step-derivative equations of inertial motion of the type (10) and (11) equate an acceleration created by a semi-fictitious force (on the left) with an acceleration created by a fully fictitious force (on the right).

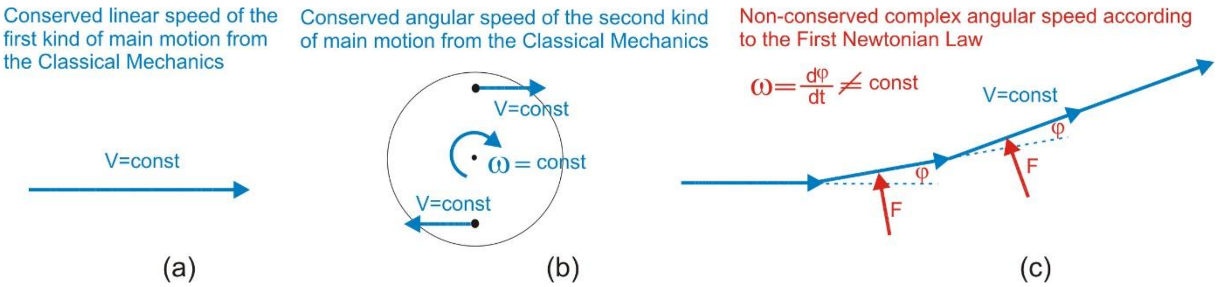


Figure 4. (a) and (b) Conserved Linear and Angular speeds of the two main kinds of motions from the Classical Mechanics. (c) Non-conservatory complex angular speed from the First Newton's Law.

In order to navigate more easily, solutions can be sought on both sides of equations (6) to (8). It is obvious that the fathers of Classical Mechanics found a solution on the left side, declaring the forces to be fictitious (doubly fictitious), and we do not deal with that. We allow ourselves to claim that this solution that these forces are fictitious is superficial, because it does not reach the essence of the problem, but only "freezes" it. The "We don't deal with that" solution helps solve the problem even less. The only possible solution is in the essence of the product of two speeds on the right side of the equations. Justified by Newton's First Law, if inertia conserves the direction of linear velocity, then the angular rate of change of direction of linear velocity is no conserving (Figure 4 (c)).

The point is that when we write the product of the two speeds on the right – hand side of the step derivative equations (6) to (11) we are not actually writing the product of the conserved speeds $v\omega$ of the principal motions of the Classical Mechanics, which we only know (Figure 4 (a) and (b)). Instead of this we record a non-conservative complex angular speed $v\omega$ in terms of its two components (Figure 4 (c)). We should know this because the records $v\omega$ and $v\omega$ look identical.

The speed $v\omega$ is called complex because its two components are mutually related, unlike the isolated speeds $v$ and $\omega$ from $v\omega$ of Classical Mechanics. We do not know this complex speed because we have ignored the inertial potential of the changed direction as an alternative factor (inertial potential). But when we write the two components of the complex speed in the Step Derivative Equations, then their true meaning of equations equating non-conserved forms of motions becomes apparent. We already equate something that changes to something that doesn't conserve. On the other hand the complex speed remains a speed, (it is still a speed, not acceleration). After the forces cease to act, the derivatives of motion of both sides of equation drop down one step of power. It turns out that we have traded conserved speed for conserved position. Seen this way, the Step Derivative Equations already satisfy Nature's Rule to equalize conserved for conserved and non-conservable for non-conservable forms of motions, even if they are of different degrees of derivatives.

We can systematize that Nature does not equate fundamental to fundamental, semi-fictitious to semi-fictitious, fictitious to fictitious forces, or motions of equal degrees of derivatives. The rule of Nature is to equalize non-conserved motions existing under the action of external forces, whatever they may be, or conserved motions which are the result of the action of the same external forces.
Mathematically complex speed can be expressed by the complex number model, of course with appropriate caveats. This helps us in analyzing complex nonlinear inertial systems.

**The experiment with the two or three flywheels**

We apply the Scientific Principle. Simply put, it boils down to observation, analysis, syntheses and most importantly, experimentation. In fact, the experiment is the scientific way to verify the Truth. This is in contrast to the religious way of verification, trough Faith, for example the belief that this is not possible. (We do not deal with this because we believe it is impossible).

The experimental set-up consists of a central shaft fixed by two bearings to the foundation (Figure 5). On the left is attached the stator of the main electric motor, to the rotor of which the main flywheel is attached. A fork is attached to the right part of the central shaft. Inside the fork, two identical auxiliary motors are connected, but so that their axes of rotation are perpendicular to the axis of the central shaft. The auxiliary motors drive two identical auxiliary flywheels. All motors are powered by current-carrying rings.

Two kinds of experiments are carried out:
*First:* The Two Flywheel Experiment:
Auxiliary motors are switched off. We turn on the main motor. Electromagnetic fields exert equal and opposite torques on the rotor and the stator. The rotor accelerates the main flywheel on the left; the stator accelerates the cluster on the right. At this point we exchange acceleration from the left for a proportional acceleration from the right, according to the plane equations (Figure 1), both motions are forced, non-conservative. This is how rockets fly, and not only them. This is how all man-made and living nature movers work.

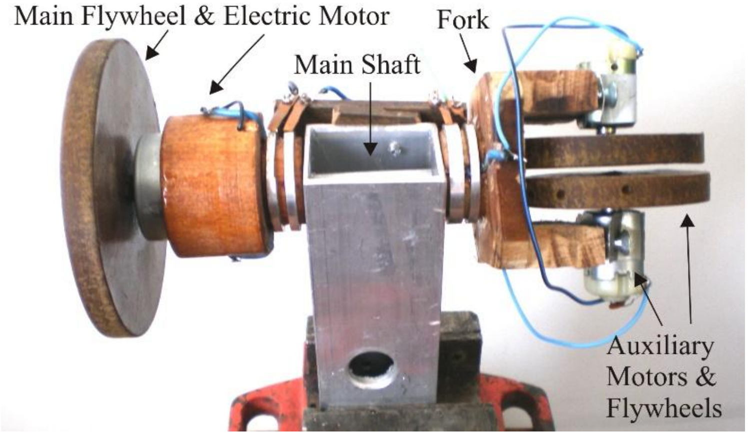


Figure 5. The experimental set-up of the experiment with the two or three flywheels.

After some time we turn off the main engine. The inertia of the masses on both sides preserves the angular speeds reached. Again we have an equality of plane derivatives of motion. The amounts of motion on both sides are equal, as the Law of Conservation of Angular Momentum dictates. If on the left we have 100, then on the right we also have 100, that is 100 = 100, and since 100 -100 = 0, it turns out that we have not created a new, in the sense of unbalanced, motion. The amount of motion in the closed system always remains a constant quantity. The experiment is a triumph of the existing theory, and for the Law of Conservation of Angular Momentum.

*Second:* The experiment of the Three Flywheels.

First we turn on the auxiliary motors. The auxiliary flywheels are accelerated in opposite directions until the rated rotation is reached. The reactive torques of the acceleration is in mutual balance.

Before turning on the main engine, we need to pay attention to the capacity of the rotating flywheel to maintain the plane of its rotation. This long-known property lies at the heart of the inertial navigation. A rotating flywheel maintains its plane of rotation because it resists an external force or torque. The existence of this resistant torques is mentioned for example in [10-15]. In the case from Figure 5, the auxiliary flywheel resists the change of the plane of rotation with a torque proportional to the product of the speed of rotation around its axis and the speed with which the main motor rotates it around a perpendicular axis. The expression is very similar, even identical, to the expression for gyroscopic torque. In fact, it doesn't matter to us whether the drag and gyro torques are equal. It is important for us that the drag torque, as well as the gyroscopic torque, is a function of the product of two angular speeds, similar to (9), and is therefore an equation of step derivatives of motion. The logic of the Nature is that the gyroscopic torque about the output axis cannot be created for free. It is created at the expense of inertial resistance about the input axes of the gyroscope. In the experimental set-up the input axes are: the axis of the auxiliary motor(s) and the axis of the main shaft. In the given case we need neither the gyroscopic torque nor the drag torque of the axes of the auxiliary motors; we only need the inertial resistance of the auxiliary flywheels against the rotation of the main shaft.

We turn on the main electric motor. Magnetic forces create equal and opposite forces that act between the rotor and stator of the main motor. These forces create equal and opposite torques. One torque accelerates the main flywheel at a constant non-conserved angular acceleration, while the auxiliary flywheels begin to rotate about the central shaft at a constant non-conserved speed (see the red equation, Figure 6) under the action of the other torque. The generated by the auxiliary flywheels gyroscopic torques, balance each other. In practice, we exchange flywheel acceleration on the left for cluster speed on the right. When the main flywheel reaches rated speed or/and when we turn off the motor, the motion of on either side drops one power of the derivative down. The flywheel on the left conserves the reached speed, while the auxiliary flywheel cluster conserves the reached angular position. In fact we have exchanged angular velocity of the main flywheel for angular displacement of the cluster (see the blue equation, Figure 5). If we equate the two forms of motion in an equation, then on one side there will be a quantity of motion (speed), and on the other the angular displacement, which is not a quantity of motion. It means that we have obtained a new quantity of motion, in the sense unbalanced by any other than angular displacement.

We are not sure that we understand the theorists of Classical Mechanics declaring that the inertial force is fictitious, and we must not deal with that. But we clearly understand that we have generated on the left side of Figure 6 a completely real new (unbalanced) quantity of rotational motion at the expense of a doubly fictitious inertial resistance torque on the right side and some invested energy. Anyone interested in this can confirm or reject the results of the simple experiment.

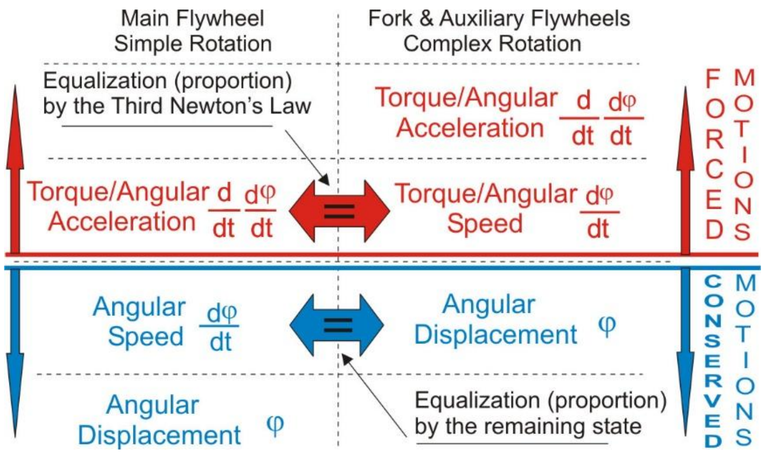


Figure 6. Illustration of the step derivative interactions during the forced and conservation periods.

Where's the thunder? Why didn't the heavens fall on our heads? And above all: Why cannot Nature protect her own well-established laws? The answer is simple: Because beyond the well-established laws of plane derivatives there are others, even more important, that we ignore.

If we make an analogy with the linear motion we see that the reactive mass of the cluster of auxiliary flywheels was not expelled, but just shifted. Such propulsion doesn't lose its reactive mass and therefore can use it throughout the vehicle's service life. Can we attribute such propulsion to the desired "propellant less" or "reactive less"?

**The Large Load Experiment**

This is another experiment validating the step derivative equations, chronologically created after the above one, approximately twenty years ago. It is based on SDD (Sector-rated in diametrical direction) Flywheel. This is an advanced flywheel conceptually described in [16,17]. The flywheel has the ability to rotate at a complex speed about its axis, resembling the complex speed of the auxiliary flywheels from the previous experiment. Like these, complex speed creates resistive torque that is not a result of friction, but obviously it is a kind of inertial resistance.

The large load experiment setup is described in [15]. Video demonstration is available here [18]. The experimental setup consists of a large wheel for the center of which an experimental device equipped with an SDD Flywheel is attached. The inertial moment of the wheel is approximately 32,000 greater than that of the SDD Flywheel, and imitates the large inertial moment of the vehicle. The device has its own power supply, and is remotely controlled. The whole cluster is suspended freely 1.5-2 meters above the ground by fishing line, never twisted before (Figure 7).

The experiment consists of four periods:
First period: The cluster is in relative rest. We remotely turn on the motor in point 1, Figure 8. It exerts a torque accelerating the SDD Flywheel, while an equal and opposite torque accelerates the fuselage of the device and the associated wheel in the opposite direction. We exchange acceleration for acceleration according to the equations of the plane (Figure 1) derivatives. The SDD Flywheel's ability to create complex rotation is of minimal importance during this period. The first stage ends when the SDD Flywheel reaches some nominal speed in point 2, Figure 8. At this point, the quantities of motion on both sides are equal.

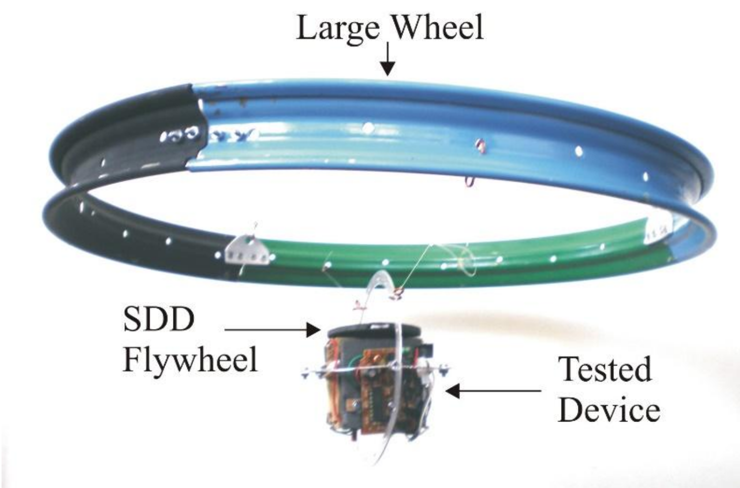


Figure 7. Large Load Pendulum Test

Second period: The rotor torque overcomes the resisting torque of the SDD Flywheel, maintaining a constant complex speed. But the equal and opposite torque of the stator continues to accelerates the simple rotation of the large wheel with constant acceleration. The inertial dependence is expressed by step derivative equation like (11). During this period we trade SDD Flywheel speed for large wheel acceleration. To achieve a noticeable increase in wheel speed, we can continue the stage from 30 seconds to 2-3 minutes. When we decide, we turn off the motor in point 3.

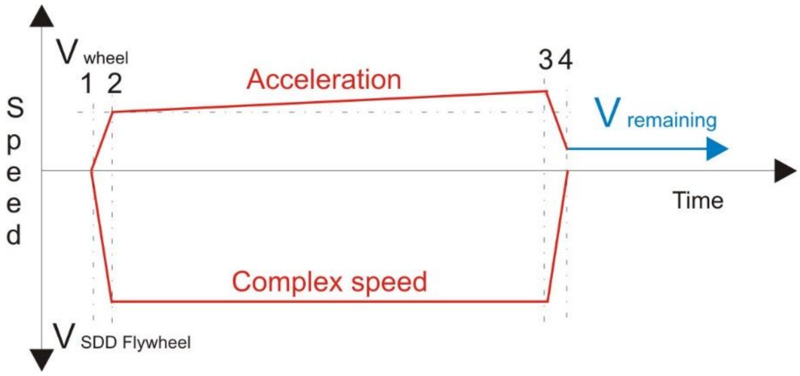


Figure 8. The periods of the large load pendulum test.

*Third period*: By turning off the motor we observe a reverse exchange of the amounts of motions between the SDD Flywheel and the large wheel accumulated during the first period, and therefore they are reset. But in the second period, the large wheel has accumulated an additional amount of motion while the rotor has kept the complex speed of the SDD Flywheel constant (Points 1-2, Figure 8). Therefore, if after turning off the motor the speed of the SDD Flywheel drops to zero, then the large wheel continues with the quantity of motion accumulated in the second period.

The *fourth period* is the residual state. The SDD Flywheel is at rest, and the large wheel conserves the quantity of motion accumulated during the second period. The quantity of motion is not balanced by anything. It turns that we exchanged some speed of the large wheel for some angular displacement in the opposite direction of SDD Flywheel.

But that's not all. Since the inertial moment of the large wheel is much greater than that of the SDD Flywheel, it soon engages the SDD Flywheel, and the entire cluster begins to move at the same residual speed. The direction of this speed is opposite to the direction of the angular displacement of the SDD Flywheel, at the expense of which this speed was achieved. Therefore, over the time, the angular displacement of the SDD Flywheel relative to a stationary observer steadily decreases, then becomes zero, after which new angular displacement in the direction of the large wheel's motion begins to accumulate. Over time, the traces of creating the new quantity of motion are erased. The only clue that remains is the constant angular lag of the SDD Flywheel relative to the wheel, but this is difficult to detect by an outside observer.

Let's interpret what we see in the video: If the two bodies were connected by plane differential equations like ones from (1) to (5) (for rotational motion), then during the second period they should be moving away in opposite directions with accelerations inversely proportional to their moments of inertia [18]. That is, if the difference between their moments of inertia is approximately 32,000 times, then the SDD flywheel should be moving away with an acceleration approximately 32,000 times greater than the acceleration of the large wheel. But this clearly does not happen, it is seen that instead the SDD flywheel moves at a constant speed while the large wheel accelerates. We continue the analysis: therefore, if before the motor was turned off the large wheel reached a speed of approximately two revolutions per minute, then the SDD flywheel should have reached a speed of approximately 64,000 revolutions per minute, or at least some similar speed. But it is seen that instead the SDD flywheel moves at a much lower constant speed. We continue the analysis: after the motor is turned off, the wheel maintains the speed it has reached of approximately two revolutions per minute. The flywheel should also maintain an opposite speed of about 64,000 revolutions per minute, or at least maintain the much lower constant speed at which it was spinning. But instead, we see that the flywheel speed drops to zero, then begins to spin in the opposite direction to the wheel speed.

The video shows the operator waiting about half a minute to make sure that the entire cluster is moving at a constant conserved speed, according to the First Law. We will emphasize that according to the Law of Conservation of Angular Momentum, if the cluster is rotated at two revolutions per minute, then there must be another mass that is moving with the same amount of motion but in the opposite direction. But there is no such mass. This should be the mass of the flywheel, but we see that it is not rotating in the opposite direction at 64,000 revolutions per minute. Instead, the SDD flywheel is carried by the large moment of inertia of the big wheel and rotates at its speed. We just changed the constant amount of rotational motion in our Universe and nothing happened, it didn't collapse!

The Universe is a closed system. In this system, by the definition of the Laws of Conservation of Momentum and Angular Momentum, the sum of all linear and angular quantities of motion of all bodies belonging to our Universe (calculated separately for linear and angular motion) are constant values and cannot change under any circumstances or conditions. Only an external force or torque can change these constant values. That is, only a force or torque applied from a place outside the Universe to bodies in the universe can change these values. Obviously Mach's Principle underlies the logic of these laws. Therefore, if we refer to it, then perhaps at the moment when the entire cluster is rotated in one direction, somewhere on a distant star, somehow another identical wheel or cluster is rotating in the opposite direction at two revolutions per minute. This is an absolutely necessary condition in order not to change (or violate, if you prefer) the sum of the rotational quantity of motion of all bodies in our Universe, as dictated by the Law of Conservation of Angular Momentum. We don't know if this is really happening on a distant star, or on a planet orbiting that star, or in another dimension of space-time, and so on. But here on our planet, in the foreseeable vicinity, we do not notice such a movement. Therefore, we can say that factually we observe a newly created motion, in the sense of unbalanced with another equal and opposite amount of motion.

But is the creation of this new motion reversible? That is, can we reset this new motion, just as we created it? The operator turns the electric motor on in the opposite direction, and the four periods of Fig. 8 are repeated in the same sequence but in the opposite direction. The operator deliberately turns the motor off early to show the different stages of the decreasing speed. Then the operator deliberately turns the motor on and off for different small periods of time to show the inertial effect. Finally, the operator lets the wheel spin at a negligible speed. Yes, we can create a new rotational motion and reset it.

**What is actually Reactionless Motion? But how is this possible? What is actually being violated?**

**What is actually Reactionless Motion?**

For centuries, the debate over Reactionless Motion has centered around Newton's Third Law. And those who have argued that Reactionless Motion is possible have imagined it as motion caused by a single force without an equal and opposite reaction, and those who have argued that Reactionless Motion is impossible have imagined it exactly that way. This is probably true in historical terms: Everyone imagines the heroism of Baron Munchausen who pulled himself out of the swamp with his horse by pulling himself by the hair, somehow eliminating the equal and opposite force. Now we can say that this notion is archaic, although very well established. One example of this well-established thinking is the comment of a scientist in [18]. If the Author has understood correctly, the comment means the following: "Look, you claim to demonstrate reactionless motion (which according to well-established opinion can only mean that the Third Law is violated, because Reactionless Motion can only be created if the Third Law is violated), but the oscillation of the test device shows that there are equal and opposite torques acting between the device and the wheel. Therefore the Third Law is not violated because, the torque couple exists, and therefore you are mistaken. You are not demonstrating Reactionless Rotation."

The Third Law is not violated. But the inertial effect of equal and opposite quantity of motion, which the Third Law is supposed to create, is violated. The motion is reactionless not because the equal and opposite reaction is canceled, but because the equal and opposite quantity of motion is changed, in fact it is replaced by a displacement of the reactive mass.

We can realize that we are not actually using the force, but instead we are using the inertial effect that the force should create by definition. If we continue along this line, we may realize that inertial motion is connected in several successive steps of transformations. Force creates acceleration. Acceleration creates velocity, that is, quantity of motion, that is, kinetic energy. Velocity creates displacement. Of all these categories are forms of inertial motion, the most important is the last one, displacement, because the ultimate goal is to move the vehicle from point A to point B, right? But in order for there to be displacement, there must be velocity. Back along the chain, in order for there to be velocity, there must be acceleration, and acceleration is created by force. At all levels, there must be balance, equality, and opposition: $F_1=F_2$, $m_1a_1=m_2a_2$, $m_1v_1=m_2v_2$, and $m_1s_1=m_2s_2$. That is why Reactionless Motion does not only mean $F_1\neq F_2$ but also it can be $m_1a_1\neq m_2a_2$, or $m_1v_1\neq m_2v_2$, or $m_1s_1\neq m_2s_2$. All of them are qualified under one common denominator - Reactionless motion.

Now imagine that one of the equal and opposite forces is applied to a foundation. It is stationary (relatively) by definition, whether there is an applied force or no applied force. Therefore, we cannot take advantage of the inertial effect of an accelerating foundation whether we have applied a force or not. Therefore, $m_1a_1\neq m_2a_2$, $m_1v_1\neq m_2v_2$, $m_1s_1\neq m_2s_2$ are valid regardless of the validation of $F_1=F_2$. This motion is also Reactionless because $m_1a_1$ is not balanced by the equal and opposite reaction of $m_2a_2$, as $m_1v_1$ is not balanced by the equal and opposite reaction of $m_2v_2$, as $m_1s_1$ is not balanced by the equal and opposite reaction of $m_2s_2$, although $F_1$ is balanced by the equal and opposite reaction of $F_2$.

We all stare at the myth of Baron Munchausen and declare: "Reactionless Motion violates the Third Law, which means the only way to create Reactionless Motion is to violate the Third Law, and therefore if the Third Law is not violated, there is no Reactionless Motion." And we fail to notice that force does not act in empty space, but acts when applied to a mass that performs a movement (or does not perform) under the action of this force. That is, in addition to the force factor, on the other side of the equation there are at least two more factors (arguments): mass (inertia) and motion (acceleration, speed, displacement). Of course, this omission is completely explicable because we have never dealt with this following the well-established instructions "We do not deal with this" [19].

So, Reactionless Motion is not only or precisely an inequality of forces, but it is primarily disproportionate (inversely proportional to their masses) the displacements of the active and reactive masses. It is obvious that some (such as Baron Munchausen) create a disproportion of displacements through a disproportion of forces. But we can't. That's why it should be clear by now that we are going the other way: We create a disproportion of displacements not through a disproportion of forces, but through a disproportion of the inertial effects that equal and opposite forces create. In our case, we change the argument of one of the forces from $ma$ to $mv\omega$. We create neither new mass, nor new inertia, nor new motion. We simply replace one motion in Nature's nomenclature (acceleration) with another motion $v\omega$. As a result of the replacement, we obtain motions with different arguments on the scale of the derivatives of inertial motion, Fig. 2. This motion is Reactionless in the spirit of Newtonian Mechanics, because if $m_1a_1= m_2v_2\omega_2$ instead $m_1a_1=m_2a_2$, then $m_1a_1$ is not balanced by equal and opposite reaction $m_2a_2$ (or vice versa), as well as $m_1v_1$ is not balanced by equal and opposite reaction $m_2v_2$, and as well as $m_1s_1$ is not balanced by equal and opposite reaction $m_2s_2$, although $F_1$ is balanced by equal and opposite reaction of $F_2$.

This is the reason why the Author uses the term "Reactionless Motion" instead of the well-established "Reactionless Drive" and "Reactionless Trust". "Trust" means force, "Drive" means movement under the influence of force. The use of these terms betrays the intention to achieve a Reactionless displacement by changing the forces, just as Baron Munchausen did. But forces are only a necessary but not sufficient condition for motion. Therefore, instead of changing forces, our attention is directed to the other conditions forming the motion, and therefore to the motion, not to the forces. Therefore, the term "Reactionless Motion" is more appropriate because it is universal addressed to all forms of motion instead to forces, and because it means that our goal is to create Reactionless Motion (displacement), not Reactionless force.

**But how is this possible?**
And so, the Newtonian Mechanics predict that equal and opposite forces/torques must inevitably produce equal and opposite quantities of motion by the Second Law: $F_1=F_2$, $m_1a_1=m_2a_2$, $m_1v_1=m_2v_2$, $m_1s_1=m_2s_2$. Yes, this is so, and NO, this is not always the case, that is, this may not be the case. It turns out that Nature has in its nomenclature not only one type but at least two types of inertial effects created by forces.

If we carefully examine the equations of the Plane Derivatives ((1) to (5)), and then the equations of the Step Derivatives ((6) to (11)), we will probably want to establish that both types of equations have the Third Law at their basis. In other words, both types of controversially equations, leading to controversial conclusions, are constructed on the same physical and theoretical basis. We always write down the basic equality of equal and opposite forces or torques. Then we develop this basic equality on the left and right by replacing the forces with the inertial effects that they create. If we replace on both sides with inertial effects of the same class, we will obtain an equation of the Plane Derivatives because on both sides we will have equality of the same derivatives of the displacement. If on both sides we replace the inertial effect of the acceleration according to the Second Law, we will have an equality in which the arguments on both sides will be second derivatives of the displacements (of the same class). And this is the only case where one quantity of motion of one body is balanced by equal and opposite reaction of equal and opposite quantity of motion. But if on one side we bring an argument of the second derivative of the displacement, and on the other side an argument of the first derivative of the displacement, then we will learn an Equation of Step Derivatives where the quantity of motion is not balanced by equal and opposite reaction of equal and opposite quantity of motion. Where is the Third Law violated here?

But are these theoretical substitutions physically (inertially) possible? Many people say "yes, this is one of many theories, but it has not been proven experimentally". In fact, the chronology is exactly the opposite: The author managed to create a series of successful experiments more than twenty years ago. And only then did he create a theory explaining the results. That is, a theory on experiments was created here.

**What is actually being violated?**

But if the Third Law is not violated then what about the so-called "Violation of Well-Established Natural Laws"? It seems that Physics (Mechanics) makes the mistake of looking at each of these laws separately, piece by piece, each for itself. In fact, these laws turn out to be connected in a hierarchical structure. They possess different degree of universality and level of connection with other laws. This should be the subject of a special discussion. An example is in paragraph 7 of this article "About Mother Nature's Rules" we gave a deviation to the rule that "something that is conserved cannot be equal to something that is not conserved". In fact, in this way we relied on the Law of Conservation of Energy, instead of relying on the Law of Conservation of the Quantity of Motion (Momentum and Angular Momentum). In this way, we entered in the hierarchy of the Conservation Laws,  by referring on a law with a higher universality to overcome a law with a lower degree of universality.

So, what is the Violation of Well-Established Natural Laws? First, the Violation cannot be physical, that is, perceived as a physical breaking or breaking of the laws, such as cutting off with a scalpel one of the equal and opposite forces, physically removing it. No human being can do this, much less the Author. Even omnipotent Nature cannot violate itself. That is to say, when the caster in the video [18] spun without balanced by equal and opposite amount of movement, this does not happen because well-established natural laws are violated, but quite the opposite. This happens only under the action of the same natural laws, albeit not well-established ones. Therefore, the Violation cannot be physical. If we insist so much on there being a Violation, then we will say that the Violation can only be theoretical, because only our well-established theoretical ideas about the physical nature of the Natural Laws can be Violated. And also because this is the only kind of Violation that a person can commit. This Violation occurs by introducing into the game new territories in which new inertial dependencies operate. These inertial dependencies are not new because they are unknown. These inertial dependencies are new because they have been ignored throughout the long period of development of Classical Mechanics, because they were considered fictitious and because we were forbidden to deal with them. Therefore, the new territories with fictitious forces actually have always been an inseparable part of Classical Mechanics. Even, if you want to legally, the fact that Classical Mechanics calls these forces fictitious means that First: Classical Mechanics recognizes their existence, and Second: in its desire to distance itself from them by calling them fictitious, it recognizes that they are part of it, that is, they are part of the Mechanics that we do not wish to deal with. Therefore, being connected with Classical Mechanics, in fact the territories of fictitious forces correspond to it. This is natural because forces and torques, linear and angular accelerations, velocities and displacements operate in the new territories, just like in the old territories, and this predetermines correspondence. A moment ago we said that the only Violation that one can make is the theoretical one. But it turns out that even the accession of new territories cannot be qualified as a Violation, if this accession is according to the Principle of Correspondence. Let us assume that the Principle of Correspondence is the most important theoretical principle in Physics (the most important Scientific Principle of Experiment, elevates the Experiment as the only final judge of all theoretical disputes). In fact, the Principle of Correspondence regulates the order in which new territories can be annexed to the old ones. Science can expand by annexing new territories only if they correspond to the old ones. Correspondence means that there must be common categories that make it possible to establishshould a path, a logical causal and mathematical connection, along which we can enter the new territories from the old ones, and then return back. Therefore, I beg your pardon, but the annexation of corresponding territories cannot be defined as a Violation. Instead, this is a perfectly legitimate development. Instead, it is a Violation to reject all of this. But then where is the Violation? If we insist to find it so mush, the Violation is in the 250-year-old doctrine "We don't deal with that" which essentially violates the Scientific Principle, and not only that [19]. The Violation is in the almost superstitious fear of the Violation instilled over the centuries. The Violation is in the irritation we feel when someone challenges our well-established notions.

## Some more analysis for the last time. Consequences, Dark Matter, Dark Energy

### Some more analysis for the last time

We have mechanics that recognizes the inertial dependences of the equations of plane derivatives ((1) to(5)), but does not recognizes those of the step derivatives ((6) to (11)) because it considers them to be fictitious. Our mechanics accept the inertial potential of the changed speed, but not that of the changed direction (Figure 5). Our mechanics accepts the two conserved speeds (Figure 4 a, b), but does not accept the existence of the non-conserved complex speed from Figure 4 c. The mechanics we have are restricted, with a highly limited (self-limited) capacity to explain inertial phenomena. This makes the mechanics we have primitive in nature.

This mechanic takes the Laws of Conservation as unconditional, that's what laws are for. But this is true only in the territory of the Linear Dynamics. There is nothing unconditional in Nature outside. There are different conditions. We will focus on only two of them addressed to the Conservation of Angular Momentum.

*First Condition:* We can equate either only conservation or only non-conservation forms of inertial motion.

*Second Condition:* The equations should relate only displacement derivatives of one rank.

Only if both conditions are met, the Law is satisfied. For example, both conditions are met for the two flywheel experiment of Figure 5. This is evident from the Plane Derivative equations describing the experiment (12) and (13).

$$J_{mflywheel}\frac{d\omega_{mflywheel}}{dt} = J_{fork}\frac{d\omega_{fork}}{dt} \quad (12)$$

$$J_{mflywheel}\omega_{mflywheel} = J_{fork}\omega_{fork} \quad (13)$$

$$J_{mflywheel}\frac{d\omega_{mflywheel}}{dt} = 2J_{auxflyw}\omega_{auxflyw}\omega_{fork} \quad (14)$$

$$J_{mflywheel}\frac{d\omega_{mflywheel}}{dt} = \omega_{fork} \quad (15)$$

$$J_{mflywheel}\omega_{mflywheel} = \varphi_{fork} \quad (16)$$

We cannot violate the first condition. Forcing us to equalize non-conservative forms of motion only, we can easily circumvent the second condition by substituting on the right-hand side of (12) the non-conserved complex speed creating drag torque, similar (8). We did it experimentally in the three flywheel experiment of Figure 5. We receive a Step Derivative Equation (14).

In writing (12), (13) and (14) we followed the logic to satisfy Newton's Third Law with non-conservative torque-producing motions. Next we need to establish the balance of the forms of motions acting on the main shaft. Since the expressions for the angular acceleration are geometrically linear (1D), they act entirely along the main shaft. But the expression for the complex speed is geometrically spatial (3D). Only one component of the spatial (3D) geometry, but the angular speed of the fork $\omega_{fork}$ , acts on the main shaft. The other component of the spatial geometry of the complex speed $J_{auxflyw}\omega_{auxflyw}$ is perpendicular and it has no projection on the main shaft. Therefore it is isolated geometrically from the main shaft. Moreover, in the specific case of using two identical auxiliary flywheels from Figure 5, the two equal and opposite $J_{auxflyw}\omega_{auxflyw}$ are mutually balanced, so they do not produce net inertial effects on the main shaft. One reason is fundamental and the other is technical. The two reasons overlap (even one of them is enough) and confirm the conclusion that we must exclude $J_{auxflyw}\omega_{auxflyw}$ from the balance in (15) and (16).

We can think of $J_{auxflyw}\omega_{auxflyw}$ as imaginary component of the complex speed, because it is perpendicular to the real one $\omega_{fork}$. The imaginary component is involved in the formation of the quantity of the real one, because the real component $\omega_{fork}$ is equal to the left side of (14) divided by $J_{auxflyw}\omega_{auxflyw}$. But the imaginary component has no projection on the main shaft. Moreover, it is balanced by an equal and opposite one. That is why it is excluded from (15) and (16).

In fact, the disproportion between the linear (1D) geometry of the acceleration on the left side of (14) and the spatial (3D) geometry of the complex speed on the right side is transformed into a quantitative and qualitative disparity in (15) and (16). Here, this is already Non-Linear Dynamics. Non-Linear Dynamics is when we have to say that both sides of (15) and (16) are causally related though they are absolutely not equal, even their dimensions are different. Non-Linear Dynamics is when we have to legitimize the disparity in (15) and (16), which effectively overcomes the limitations of the Law of Conservation of Angular Momentum.

**Consequences, Dark Matter, Dark Energy**

Let's imagine that the masses involved in the experiments from Figures 5 and 7 as well from the video are galaxies, clusters and other masses in the universe [18]. In both experiments after the motor turned off, residual speeds remain balanced by nothing. Since the existing mechanics only handle dependences of the plane derivative equations like (12) and (13), and ignore those like (15) and (16), it cannot explain where the new quantity of motion of the main flywheel from Figure 5 comes from, if the fork is in peace. Things are even worse with the SDD Flywheel experiment from the video, where the entire cluster rotates in the same residual speed [18]. Not only can we not determine where the quantity of motion of the cluster comes from, but we cannot even determine which of the masses could be reactive.

So, imagine that astronomers see an inward-moving galactic mass similar to the rotating cluster in the video after the first motor shutdown. Who spun this mass? This is obviously not about the energy that spun this mass in the past. It's about the fact that if this mass is spinning in one direction at a given speed, then by the Law of Conservation of Angular Momentum, which is the only law we have in our arsenal, somewhere around there must be another mass spinning with an equal quantity of angular motion in the opposite direction. Astronomers look for reactive masses carrying the same but opposite quantity of motion, same as gravitational masses (these masses are also reactive), that could create that motion. But just like in the video no relevant reactive, or/and gravitational masses in the immediate vicinity is observed [18]. This puts us in a difficult position because the only laws we have cannot explain the inertial phenomenon. No one dares to think that the Law of Conservation of Angular Momentum can be "violated" as in the video. The equations of Step derivatives and Nonlinear Dynamics are unknown and rejected because they lead to a revision of the Laws, which is unacceptable, and which we do not deal with. We have no choice but to decide that the fact that we do not see these masses does not mean that they do not exist. Simply, we do not see these masses because they are invisible i.e. they are dark. This is a possible scenario that creates the idea of invisible Dark Matter or Dark Energy, as the case may be, is created.

Of cource we don't know if Dark Matter and Dark Energy exist, it's possible they really do. What we mean is that applying more advanced mechanics would probably explain at least some of the cases.

## Conclusion

What changes inertia (force, torque) cannot be created from a form of motion conserved by the inertia (conserved linear and angular speeds from the two main kinds of motion of the Classical Mechanics).

What changes inertia (force, torque) can only be created by a form of motion that is not conserved by the inertia (non-conserved acceleration from the Newton's Second and non-conserved complex speed from the First Laws).

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