Analysis of dynamics fields systems accelerated by rotation.
Dynamics of non-inertial systems.

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ABSTRACT

Starting from certain dynamic presumptions and based on a new interpretation of the behaviour of bodies which dispose of intrinsic angular momentum, when exposed to successive torques, new dynamics hypotheses have been developed, ending up with the conclusion that a new mathematical model in rotational fields dynamics can be set up. This would allow us to justify certain behaviours, until then not understood. Through this model different results are obtained, for certain assumptions, basing ourselves exclusively on a new interpretation of the composition or superposition of the motions originated by the acting torques.

We believe that the achieved results allow us to obtain a new perspective in dynamics, unknown up to date, making it possible to turn given trajectories which, until now, have been considered as chaotic, into deterministic terms. We have come to the conclusion that there still exists an unstructured scientific area in the present general assumptions and, specifically, in the area of rigid bodies exposed to simultaneous non-coaxial rotations.

For this purpose, it is necessary to analyze the velocity and acceleration fields that are generated in the body which disposes of intrinsic angular momentum, and assess new criteria in these speeds coupling. In this context, reactions and inertial fields take place, which cannot be justified by means of the classical mechanics.

It is the aim of this Paper to inform of the surprising results obtained, and to attract the interest towards the investigation of this new area of knowledge in rotational non inertial dynamics, and of its multiple and remarkable scientific and technological applications. [i]

I – Initial speculations and conjectures

It is possible to find new fields of research in new rotational dynamics of non-inertial systems. The foundations of rotational dynamics might be relevant to unsolved significant problems in physics.

Systems in the universe are in motion, in constant dynamic equilibrium. In the real universe, the general dynamic behaviour of rigid solids is characterized by its dynamic equilibrium. Through time, orbitation coexists with the intrinsic rotation. This aporia, and also the professor Miguel A. Catalán[ii] conjectures were our initial speculation.

The importance of our mathematical model is obvious. In this model not only the forces are leading players, but also the momentums of those forces which, while staying constant, will generate orbiting and constantly recurrent movements, generating a system in dynamic balance, and not being in unlimited expansion. This new dynamics theory will give us a better understanding of how universe and matter behave.

We would suggest a detailed and deep analysis of these dynamics hypotheses and propose continuing experimental testing necessary for confirmation.

II- Investigation project

We have been involved in an investigation project of non-inertial systems, to know the behaviour of rigid bodies exposed to simultaneous non-coaxial rotations. As a result of this investigation we have proposed new hypotheses in order to explain the dynamic behaviour of these bodies, insisting on the need of extending our studies on field theory.

We define the inertial reactions that are manifested in the matter, when it is subjected to accelerations, as *Dynamic Interactions* (ID). These are manifested in nature at any scale of magnitude. Any physical system and boundary conditions can be represented by a Lie group. The phase space of this dynamic is described in a quaternionic Kähler variety of 8-dimensional symplectic geometry. This would have two types of field's forces simultaneously: one corresponding to the actual applied forces and the other corresponding to inertial forces due to the *dynamic interactions* (ID) generated.

According to the *Relativity Principle of Galileo*, physical laws are identical in any system of *inertial reference*. The Classical Mechanics, and even the majority of modern physical theories, have been formulated for inertial reference frames, their validity having been proven in said systems.

Nevertheless, beyond these limits, in our opinion, there may be other assumptions in nature for which we nowadays still do not know exactly the laws to explain their behaviour, because the models of analysis we use are wrong. An example of this is the analysis of rigid solid bodies equipped with rotational movement. It is necessary in these cases to take into account possible inertial reactions.

The composition or superposition of the motions was understood also by Galileo to explain the *path* of a canyon ball. The question is to understand the superposition of fields originated by acting torques. We shall use the expression "coupling" in relation with the composition or superposition of the velocity field that are generated in these cases.

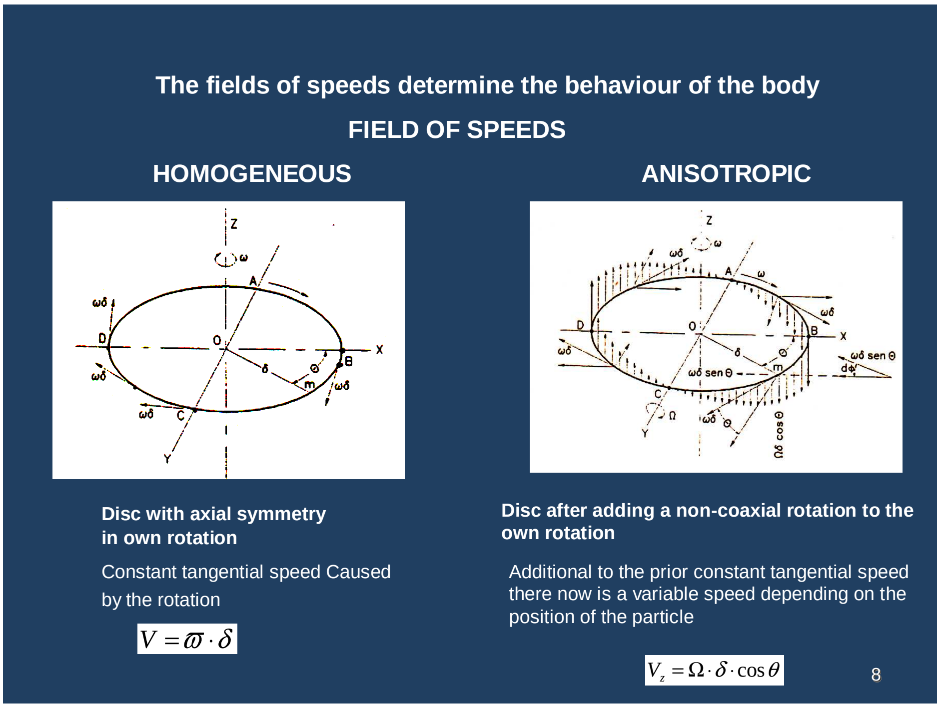

Figure I. The fields of speeds determine the behaviour of the body.

III- Rational deduction

This new non-inertial and non-Newtonian rotational dynamics of accelerated rigid solid bodies can be inferred in different ways: relativistic deduction, through equations of the generated fields, or through a rational deduction. We will concentrate on the last supposition.

In the case of a flat disc rotating around its symmetry axis, a field of speeds due to the rotation of the disc can be identified. In each particle of the disc, the generated tangential speed, will be identified in line with the equation:

$$\vec{V} = \delta\vec{\omega} \qquad (1)$$

With

δ: Distance from the particle to the rotation axis.

$\vec{\omega}$: Rotation speed of the disc.

δ is also the circumference radio or the geometric place that contains the particles that are equidistant to the rotation axis and whose dynamic state we are analysing.

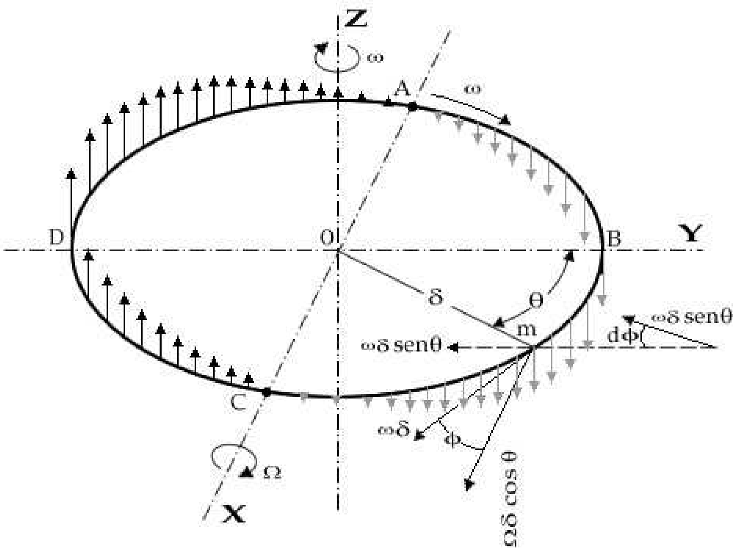

Figure II. In a body with $\vec{\omega}$ speed rotation on its principal axis, when it is subjected to a new no- coaxial rotation $\vec{\Omega}$, a non-homogeneous field of speeds is generated.

Therefore, all the particles situated in that circumference will have the same module of tangential speed but with a different orientation. As such, we obtain a homogeneous and balanced field of speeds as the result of the turn of the disc on its symmetry axis, figure I.

In the assumptions of simultaneous non-coaxial rotations, the rigid body experiences non-homogeneous speed fields, figure II. These fields generate anisotropic acceleration fields. These acceleration fields can be interpreted as fields of inertial forces, created in space through the effect of simultaneous non-coaxial rotations, figure III.

This rational deduction can be enlarged via an analysis inside the Fields Theory and its equations.

IV- Initial Paradox

We now express a paradox that permits us to introduce the concept of rotational inertia. When a body, with rotating intrinsic movement, is not submitted to external forces (or to its moments), according to the equations of Newton-Euler's mechanics:

$$d/dt\,(I\boldsymbol{\omega}) = 0 \qquad (2)$$

Result: $\boldsymbol{\omega} = Const.$,

Where I is the moment of inertia of the body, and $\boldsymbol{\omega}$ is its angular speed. The angular speed will be kept constant eternally due to its inertia.

Any rotation is an accelerated motion, since the linear velocity of every particle of the rigid body, though it remains constant in module, it will be constantly changing position. But being ω constant, we find the contradiction of having the example of a rotating movement accelerated by inertia, without any external force. This allows us to suppose the existence of one **Rotational Inertia**, fundamentally different from the Translational Inertia.

The Rotational Inertia would correspond to the inertia of the body when it has a movement of rotation; it will tend to maintain this rotation, despite the cessation of forces acting on it.

From the concept of rotational inertia, it is easy to infer a dynamic model based on constant rotation. A system maintains a constant angular speed when two points of the system remain in time, on the same dynamic state. In this case the system is in a state of **constant rotation** on a fixed axis.

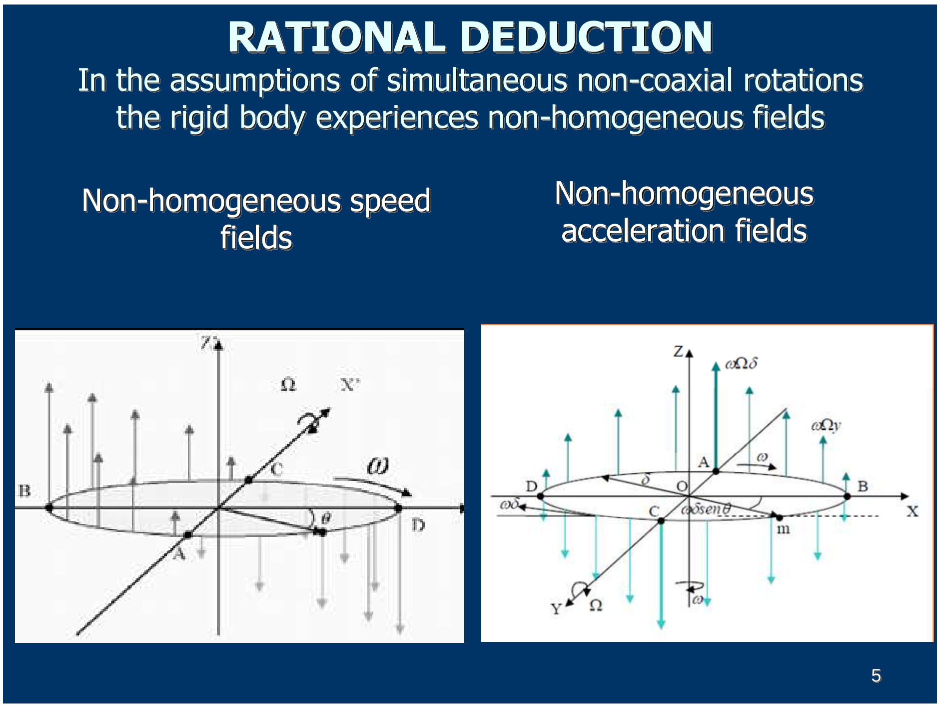

Figure III. Rational deduction

V- Axioms

The rotational dynamics based on the assumption of inertial reactions, is based on the principles of conservation of certain measurable quantities: **the motion quantity, the total mass and total energy**, and in this concepts: **Dynamics interactions, speed coupling, rotational inertia** and **constant rotation.**

From these principles of conservation of measurable magnitudes, and after the observation of the inertial reactions that occur in nature, we can deduce certain specific axioms:

1. **The rotation of space determines the generation of fields**

From a relativistic point of view, an intrinsic rotation can be interpreted as a fixed moving element plus a turn of the space of events which contains it. In a given body, two simultaneous non-coaxial intrinsic rotations can be generated around different axes. Two simultaneous intrinsic non-coaxial rotations of a given body, can be interpreted as two rotations of the space of events around different axes. The rotation of space determines the generation of anisotropic speeds and accelerations fields.

2. **Result of the action of non-coaxial moments**

When a solid is subjected to non-coaxial successive moments, non-homogeneous distributions of speeds and accelerations are generated. This can be identified as inertial fields.

3. **Inertial fields cause dynamic interactions**

The anisotropic speeds fields generated, interact with other fields of the rigid body, changing its dynamic state. For instance, the non-homogeneous tangential velocity field that is generated is coupled to the field of translation speeds.

4. **The action of successive non-coaxial torques on a rigid body cannot be determined by algebraic addition or calculated by the resultant force or torque**

This axiom reminds us of the impossibility of the use of vector algebra to solve these phenomena.

We understand that the inertial behaviour of the mass of the rigid solid body, when exposed to these movements has not been studied thoroughly.

VI- Motion Equation

Based on the **Principle of Conservation of the Motion Quantity,** and on the above mentioned axioms, we can obtain the motion equation.

We suppose that an infinitely flat disc with radio δ is submitted to a momentum *M*, whose axis coincides with the axis Z of the disc's symmetry. If this momentum is instantaneous, it generates a constant rotation speed $\vec{\omega}$. A second momentum ***M´***, non-coaxial with the former will generate a new dynamic state which has been defined in Classic Mechanics as the gyroscopic effect, and which is attributed to a supposed gyroscopic momentum. This explanation of Classic Mechanics does not respond to the rational structures of the rest of the theory and represents a singularity in its conceptual development, as the axis of the new generated rotation does not coincides with the axis of the torque that generates such rotation.

We can interpret that the gyroscopic momentum does not exist physically, as it is simply the observable effect of a field of inertial forces generated by the simultaneous, non-coaxial, rotation of space (First axiom). We will check this starting point further below. In any case, based on the principle of **Conservation of the Motion Quantity,** the gyroscopic momentum ***D*** will be equivalent to the one acting from the outside ***M´*** and be the one that generates the second rotation non-coaxial with the first, and therefore:

$$M' = D \qquad (3)$$

Supposing that the momentum ***M´*** will stay constant in time, it will keep its dynamic action on the body. Nevertheless, the referred gyroscopic momentum has been quantified through multiple methods of the classical mechanics with the following formula:

$$D = I\,\Omega\,\omega \qquad (4)$$

If we observe the behaviour of this disc with own rotation $\vec{\omega}$ and submitted to a new non-coaxial torque ***M´*** (second axiom), we observe that it initiates a new rotation $\vec{\Omega}$ around an axis perpendicular to the new torque ***M´,*** and not around its own axis. Therefore we can infer that the field of inertial forces generated in the rotating space by a new non-coaxial momentum ***M´***, upon a moving body with a rotatory movement $\vec{\omega}$ and an inertial momentum *I* upon that rotation axis, and thus with an angular momentum $\vec{L}$, will oblige the moving body to acquire a precession speed $\vec{\Omega}$ defined by the scalar quotient:

$$\Omega = M' / (I\,\omega) = M' / L \qquad (5)$$

The precession speed $\vec{\Omega}$ can be observed simultaneously with the initial $\vec{\omega}$, which remains constant within the body. Instead of the discriminating Poinsot[iii] hypothesis, which supposes that the angular momentums were coupled between each other and separate from the linear dynamic momentums, in the case of translation movement of the body, we propose the dynamic hypothesis which states that (Third axiom), **the field of translation speeds couples to the anisotropic field of inertial speeds generated by the second non-coaxial momentum**, forcing that the center of masses of the mobile modifies its path, without an external force having being applied in this direction.

As such, we obtain an **orbiting movement $\vec{\Omega}$, which is simultaneous with the constant intrinsic rotation of the moving body** $\vec{\omega}$. This new orbiting movement, generated by a non-coaxial momentum, is defined by **the rotation of the speed vector**, the latter $\vec{\omega}$ staying constant in module.

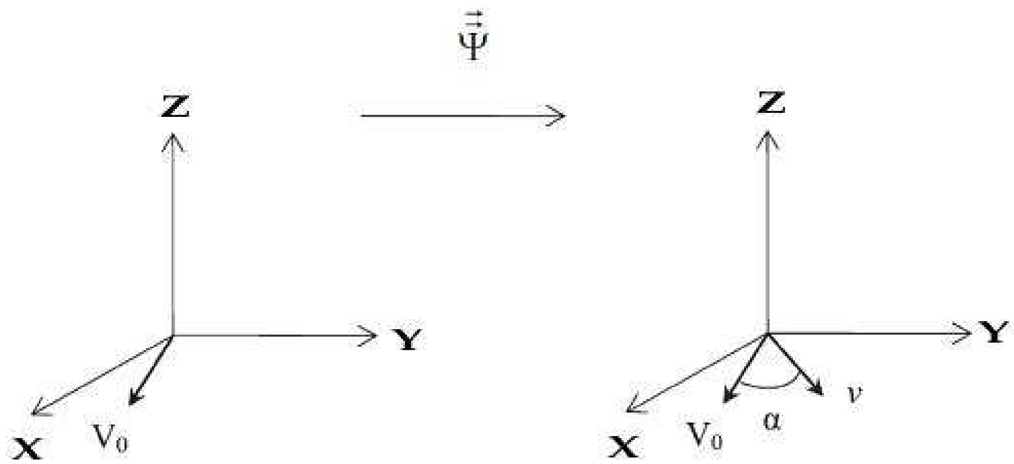

Figure IV. The rotational operator $\vec{\vec{\Psi}}$ transforms, through one rotation α, the speed vector $\vec{V}_0$ into the speed vector v, both always situated on an identical plane, in this example in the XY plane. In reality in the plane that contains the acting momentum M'

In the assumption of figure IV, the new external momentum *M´*, which is supposed to be located on the *X* axis, will generate an inertial rotation around the *Z* axis, so that if the initial translation vector $\vec{V}_0$ was located on the *XY* plane, the resulting speed will stay on that plane after the rotation. Any rotation in space can be identified by a matrix. Therefore, in our supposition, the spatial rotation matrix $\vec{\vec{\Psi}}$ will be as follows:

$$\begin{pmatrix} \cos\alpha & -\text{sen}\,\alpha & 0 \\ \text{sen}\,\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad (6)$$

And will, in our assumption, generate a turn of the referred translation vector $\vec{V}_0$ in that *XY* plane.

Given that no external force modifying the quantity of translation movement has acted on the solid, its kinetic linear momentum will have to stay constant and therefore also its translation speed. However, if we accept that the homogeneous field of translation speeds couples to the field of tangential speeds due to the torque *M´* (Third axiom); we can determine what will be the new dynamic state of the body.

In this supposition, we then obtain as **motion equation** that the translation speed of the body's masses centre has not varied in magnitude and will therefore be equal to the initial in module, but submitted to the spatial rotation mentioned above:

$$\vec{v} = \vec{\vec{\Psi}}\ \vec{V}_0. \qquad (7)$$

The non-discriminating coupling proposed in our hypothesis is therefore identified by a spatial rotation of the speed vector and therefore:

$$\vec{v} = \begin{pmatrix} \cos\alpha & -\text{sen}\,\alpha & 0 \\ \text{sen}\,\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \vec{V}_0. \qquad (8)$$

As such we obtain:

$$\begin{pmatrix} \vec{v}_x \\ \vec{v}_y \\ \vec{v}_z \end{pmatrix} = \begin{pmatrix} \cos\alpha & -sen\,\alpha & 0 \\ sen\,\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} V_0^1 \\ V_0^2 \\ V_0^3 \end{pmatrix} = \begin{pmatrix} V_0^1 \cos\alpha - V_0^2\, sen\,\alpha \\ V_0^1\, sen\,\alpha + V_0^2 \cos\alpha \\ V_0^3 \end{pmatrix} \qquad (9)$$

However, we can suppose that the new path will be the arch of a circle and the components of speed will thus be:

$$\begin{aligned} v_x &= -\delta \cdot \Omega \cdot sen\ (\Omega t) \\ v_y &= -\delta \cdot \Omega \cdot \cos\ (\Omega t) \\ v_z &= 0 \end{aligned} \qquad (10)$$

We have:

$$\begin{pmatrix} -\delta\Omega.\,sen\,(\Omega t) \\ -\delta\Omega \cos(\Omega t) \\ 0 \end{pmatrix} = \begin{pmatrix} V_0^1 \cos\alpha - V_0^2\, sen\alpha \\ V_0^1\, sen\alpha + V_0^2 \cos\alpha \\ V_0^3 \end{pmatrix} \qquad (11)$$

From which we obtain:

$$\begin{aligned} V_0^1 &= 0 \\ V_0^2 &= -\delta.\Omega \\ V_0^3 &= 0 \end{aligned} \qquad (12)$$

However, as: $\alpha = \Omega\, t$ (13)

Therefore the rotational operator $\vec{\vec{\Psi}}$ is in this supposition:

$$\vec{\vec{\Psi}} = \begin{pmatrix} \cos(\Omega.t) & -sen\,(\Omega.t) & 0 \\ sen\,(\Omega.t) & \cos(\Omega.t) & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad (14)$$

And

$$\vec{V}_0 = \begin{pmatrix} 0 \\ \vec{V}_0 \\ 0 \end{pmatrix} \qquad (15)$$

And, according to equation (5):

$\alpha = M´\, t/\, (I\, \omega)$ (16)

The motion equation finally can be written:

$$\vec{v} = \vec{\vec{\Psi}}\ \vec{V}_0 = \begin{pmatrix} \cos\ M´\, t/\, I\omega & -sen\, M´\, t/\, I\omega & 0 \\ sen\, M´\, t/I\omega & \cos\, M´\, t/I\omega & 0 \\ 0 & 0 & 1 \end{pmatrix} \vec{V}_0. \qquad (17)$$

The rotational operator $\vec{\vec{\Psi}}$ transforms, through one rotation, the initial speed vector $\vec{V}_0$ into the speed vector v, both always situated on an identical plane.

It is observed how the rotational operator $\vec{\vec{\Psi}}$ is a function of the equations of sinus or cosinus of Ω t, existing a clear relation between the angular speed $\vec{\Omega}$ of orbit and the acting torque/couple M' and the initial angular speed $\vec{\omega}$. As such, we possess a simple mathematical relation between the angular speed $\vec{\omega}$ of the body and its translation speed $\vec{v}$.

In general, the mobile's path will be defined by intrinsic coordinates by the successive speeds of the body $\vec{v}$, determined by the matrix product of the rotational operator $\vec{\vec{\Psi}}$ on the initial speed vector $\vec{V}_0$. The referred equation (7) results, as a general equation of the movement for the bodies with angular momentum, when they are submitted to successive non-coaxial torques. For this equation, the rotational operator $\vec{\vec{\Psi}}$ is the matrix transforming the initial speed into the one that corresponds to each successive dynamic state by means of a rotation.

Starting from the equation $\vec{v} = \vec{\vec{\Psi}} \; \vec{V}_0$ we can determine the surface in which all possible paths of a solid body with intrinsic rotation $\vec{\omega}$ would be present when varying simultaneously as parameters this speed or the time. As well the surfaces of paths for different speeds V_0 when those are not a constant value, but also a function of another variable.

In short, in this simplified mathematical model, it would be possible that, in space, the mobile bodies submitted to successive non-coaxial torques, as a result of inertial dynamic interactions, would initiate an orbital movement so that, while maintaining the initial angular momentum and the second torque constant, its masses' centre would follow a closed orbital path without any need for real central forces.

So we can associate **dynamic effects to speed and a clear mathematical correlation between rotation and translation**. This mathematical connection allows us to identify a physical relation between **transfers of kinetic rotational energy to kinetic translation energy, and vice-versa.**

On the analysis of the dynamic behaviour of the bodies submitted to acceleration by rotation a change of mentality is necessary. In these cases, you cannot apply the same axioms and premises as those used in inertial systems (Fourth axiom).

VII – Experimental tests and physical-mathematical simulation model

The starting hypotheses as well as the mathematical model were confirmed by a series of experimental tests and also by a physical-mathematical simulation model of this behaviour.

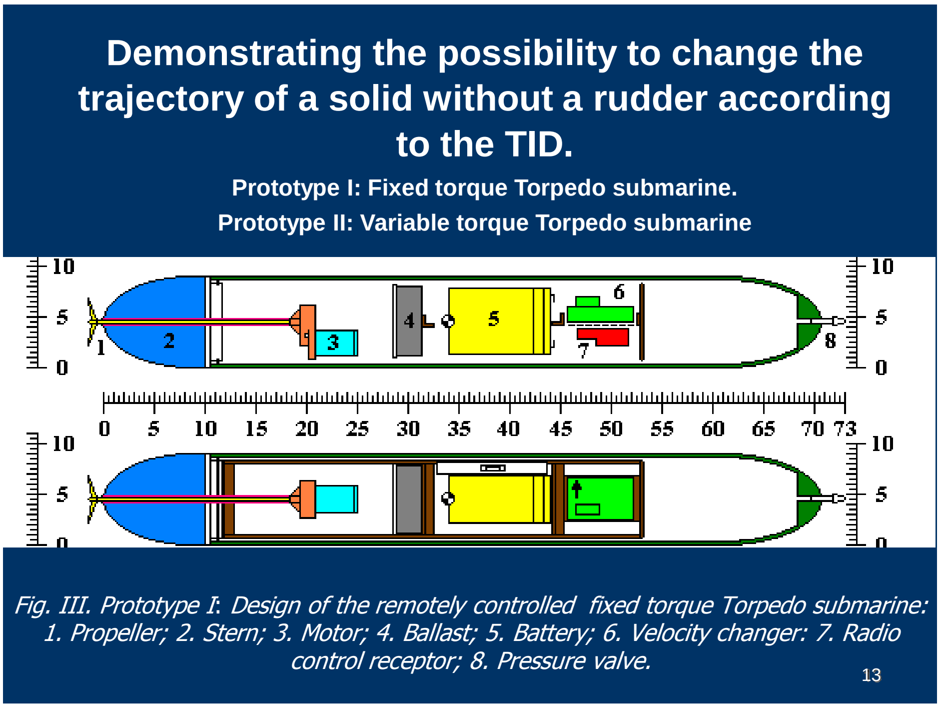

Figure V. Design of the remotely controlled submarine: 1. Propeller; 2. Stern; 3. Motor; 4. Ballast; 5. Battery; 6. Velocity changer: 7. Radio control receptor; 8. Pressure valve.

The challenge was to find a mobile with simultaneous angular momentum and linear speed. Because of the difficult availability of a device with these characteristics in space, it seemed sensible to continue the experiments with bodies floating in water. In this hypothesis, a cylinder or “Torpedo submarine” could be designed rotating around its longitudinal axis while at the same time driven by a propeller on its stern, provided as well with a gravitational torque perpendicular to the rotation axis. We make two different prototypes:

I Fixed torque Torpedo submarine, with constant unbalance.

II Variable torque Torpedo submarine, with pump and two deposits for water.

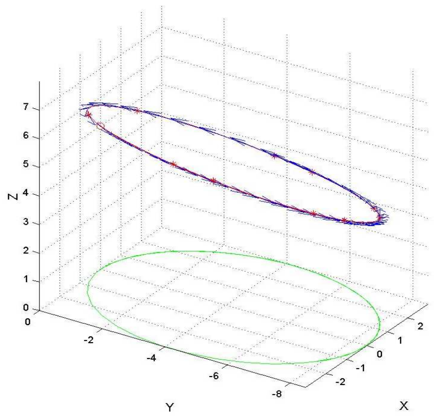

Figure VI. Path of the mass center of a mobile with intrinsic rotation and simultaneously submitted to an external momentum non-coaxial with its intrinsic angular momentum, obtained via computer simulation, in the supposed case that both, the applied moment and the translational linear speed of the mobile are constant. Simulating conditions: Tangential speed 5 m/s.

In accordance with the proposed dynamic hypotheses, a simulation of the behaviour of this solid in space, with intrinsic rotation and simultaneously submitted to an external momentum non-coaxial with its intrinsic angular momentum was realized, obtaining open or closed traces, equivalent to the trajectories of real bodies in space.

The equation of movement deducted and applied to a simulation model, determines a path that coincides with the one experimentally observed (Figure VI).

Also, quite a number of examples can be thought of for checking these dynamic hypotheses (see ***Un Mundo en Rotación***[iv]), which would allow us to interpret many, in our opinion, still unexplained assumptions in nature, using the interactions which result from rotating the space of events, as for example, the behaviour of so many rotating solid elements like the boomerang, the hoop or the wheel.

This new non-inertial rotational dynamics is developed in laws and corollaries, allowing a number of new, unknown scientific and technological applications. These *Rotational Dynamic Laws* are based on the inertial impossibility of matter to change their dynamic state in certain cases and propose the concept of ***rotational inertia*** as an *invariant of mass*. These laws are understood as a negation of nature to selective and discriminating couples established by Poinsot, and allow developing an alternative and specific *Theory of Dynamic Interactions (TID)* for bodies with angular momentum.

VIII - Conclusions

The present text is only a brief referential summary of the works carried out during the last twenty years in order to propose a *Rotational Dynamics of Interactions* applicable to bodies submitted to multiple successive non-coaxial torques. The initial hypotheses are based on new criteria about **speed coupling and rotational inertia**, and have been confirmed by experimental tests and by a mathematical model allowing the simulation of the real behaviour of bodies submitted to these excitations. A clear correlation between the initial speculations, the starting hypotheses, the mathematical simulation model, the deduced behaviour laws, the realized experimental tests and the mathematical model corresponding to the movement equations resultant of the proposed dynamic laws, have been obtained.

This research can be extended with the Field Theory and a relativistic deep analysis, and may allow the physical knowledge of new space systems and brings potential applications for the future, along with numerous relevant technology developments.

The *Theory of Dynamic Interactions* generalizes the concept of gyroscopic momentum, and of other inertial phenomena, incorporating them into the unified structure of a new *non inertial rotational dynamics of Interactions*.

According to the defended *Theory of Dynamic Interactions*, we can conceive a universe in a constant dynamic balance, in which a force momentum, with a zero resultant, will generate, as long as it works, a movement of constant orbiting, within a closed path. The importance of this mathematical model is obvious: not only the forces are leading players, but also the momentums of forces which, while staying constant, will generate orbiting and constantly recurrent movements, generating a system in dynamic balance, and not in unlimited expansion. This *Theory of Dynamic Interactions* is reasoned out and described in the book: ***Un Mundo en Rotación*** (2008), and its antecedents and fundamentals were presented in the book of the same author: ***El Vuelo del Bumerán*** (2005).

We want to suggest that interest should arise in physics in the exploration of non-inertial accelerated systems, and also to express a call for the need to develop scientific investigation projects for their evaluation and analysis, as well as technological projects based on these hypotheses. In our opinion, these hypotheses suggest new keys to understanding the dynamics of our environment and the harmony of the universe. A universe composed not only of forces, but also of their momentums; and when these act constantly upon rigid rotating bodies, with an also constant translation speed, the result is a closed orbiting movement, thus a system which is moving, but within a dynamic equilibrium.

The application of these dynamic hypotheses to astrophysics, astronautics and to other fields of physics and technology possibly allows new and stimulating advances in investigation.

The result of this project is the conception of an innovative dynamic theory, which specifically applies to rigid rotating physical systems and which has numerous and significant scientific and technological applications,

Anyone interested in cooperating with this independent investigation project is invited to request for additional information to:

gestor@advanceddynamics.net

Or to look up at:

www.advanceddynamics.net.

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i *On the Equivalence Principle,* presented by de author to the 61st International Astronautical Congress, Prague, CZ. Copyright ©2010 by Advanced Dynamics S.A. Published by the American Institute of Aeronautics and Astronautics, Inc. with permission.

ii Professor Miguel A. Catalán Sañudo. Spectroscopist. (Zaragoza 1894-Madrid 1957). Refer in *Un Mundo en rotación.* (Gabriel Barceló) Ed. Marcombo 2008, page 56.

iii Poinsot, L. *Théorie nouvelle de la rotation des corps*, 1834, refer by Gilbert: *Problème de la rotation d'un corps solide autour d'un point solide*, Annales de la société scientifique de Bruxelles, 1878, page 258 and by G. Barceló: *El vuelo del Bumerán*. Ed. Marcombo 2006, page 121.