JOHN RIUS–CAMPS

NEW DYNAMICS

EXPERIMENTAL PROOFS

ORDIS EDITIONS

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INTRODUCTION

A series of experimental tests appears here, done or observed during the years of the elaboration of a NEW DINAMICS (ND) OF IRREVERSIBLE MECHANICAL SYSTEMS. that begins in 1975. Some are already old but its explanation has only been possible when it was elaborated the theory of this ND, around 1995. At the same time the aspect physical-mathematical needed the experimental observation to save the inevitable stumbling blocks and errors.

Thus the reader will be able to judge, with better knowledge of cause, as much the theoretical findings and exhibitions, like the experimental tests.

Everything began with a Metaphysical work, published in the Philosophical Yearbook of the University of Navarre, in 1976, that allowed to see that CLASSICAL DYNAMICS (CD) was not only insufficient in the relativistic, quantum, thermodynamic, electromagnetic, expositions, etc.; but also in low speeds; as it is the case (mentioning some of the tests: the flight of the insects, the "bumming–bird", or the "disc of Faraday".

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EXPERIMENTAL TESTS

Inseparable to the creation of the theoretical framework that has been put forward here, a series of experimental tests have been carried out that confirm it and have served also to overcome many important stumbling-blocks which would otherwise have been very difficult and even impossible to deal with. The most significant of these tests are summarized here. Further explanations and details will be given in this chapter corresponding to the experimental research.

1. ***Non-aerodynamic lift in flying insects.*** This test was carried out for the first time in 1977 in the laboratory of the Pharmacy Faculty at the University of Navarra, Pamplona. Experiments were made using hymenoptera: *bombus terrestris* and with diptera: *calliphora vomitoria,* at a pressure of $13\ mb$ corresponding to the partial pressure of water vapour at $15^o\ C$. The water vapour cannot be eliminated without using a vacuum pump of the type known as a "water trunk", otherwise the insect becomes greatly deformed and cannot fly. In this rarefied fluid (*98.5%* of normal atmospheric pressure: *1013 mb*) they fly perfectly for over $1–2\ minutes$, even *hovering*, without any noticeable difference in their lift and manoeuvrability.

This study was registered in 1977. Since then it has been repeated several times by different people; always with the same results. At the end of this chapter our article in "Scientific American" appears in complete form, describing how this experimental test is performed.

2. ***Rotary mechanical system which destroys angular momentum*** related to a fixed vertical axis with negligible friction, violating the law of conservation. Registered in 1984. This extremely simple mechanism is comprised of a disc, of mass M , that rotates around vertical axis, to which an elastic vertical rod is fixed; at one end of this rod is attached another mass $m < M$ oscillating with it and rotating with the disc. The system comes to stop after a few rotations leaving only the oscillation of mass m on a vertical plane. The initial angular momentum in relation to the axis has disappeared. The initial kinetic energy has been transferred to the oscillating mass m . (See development and schemes in pp. 120-123)

3. ***Rotary mechanical system which creates or destroys angular momentum*** starting out from initial rest, or modifying that it had until a steady rotation is obtained with the initial angular momentum increasing or decreasing with respect to the vertical axis of rotation. This device consists of a disc of mass M which can rotate in relation to its vertical axis with negligible friction; an electric motor is attached in it (whose mass is included in M) with vertical axis parallel to the other one. This motor moves, eccentrically, a mass $m < M$ by means of a horizontal arm. The battery *(4.5 V)* is also fixed to the disk (and its mass is also included in M). This experiment was carried out for the first time and registered in 1984. (see a more detailed description in pp. 124-125)

4. ***Rotary motor without a crankshaft nor connecting rods*****,** based on the transformation of energy from a piston into its corresponding cylinder, without having recourse to a connecting rod-crank mechanism or similar. Two different models have been built. Barcelona, 1989.

5. ***Non-reactive linear propeller.*** It is based on the fact that m = *m(t)* in this ND and on the "uncoupling" of forces by means of kinetic energy dissipation, by friction, between two masses of the system (it must be formed by a minimum of *three*). A number of models were constructed, based on possibilities opened up by ND, but always with negative results. In May 1988 we discovered by experimentation that part of the system kinetic energy in must be *dissipated* in order to undo the *"coupling"* of forces described by ND. In this way we managed to obtain a *not null resultant of force;* this possibility is corroborated by theory since these forces depend on the velocity of each mass of the system. Supposing that the non-reactive linear propeller (LPWR) is made up of *three masses* m_1, m_2, m_3, which interact on the same straight trajectory by means of potential and kinetic energy. In addition to the forces of acceleration, anticipated by CD and whose resultant is null, there should also appear, in this particular case, the forces anticipated by ND:

$$(1/2)\sum(dm_i/dt)v_i\mathbf{s} \qquad (1)$$

where $\boldsymbol{s}$ is a *versor* according to the common straight line of action. Due to "coupling" phenomenon this resultant is also null because no propulsion is observed at all; nonetheless, by dissipating kinetic energy through reciprocal friction between *two* of the *masses,* their respective velocities will vary but this will not necessarily affect the velocity of the *third mass* (or it will do so in a very different proportion); thus the *resultant* (1) will be no longer null: the forces of ND have been "uncoupled" and this LPWR is possible. This fundamental discovery enabled the difficulties to be overcome. Since then, increasingly efficient machines have been built; the latest are very recent (1993) and run with batteries *(3 V)* and small electric motors; they reach speeds of between *15* and *40 m/min*. over *one* of the *two reciprocal dissipation masses* which completes the system. It can be clearly observed –by means of a suitable device that isolates the *total system*– that there is no reaction; in other words: *lineal momentum is created*. Flying insects' propulsion and lift are derived from what is anticipated in this ND. In the next section we shall talk about the state of investigation on insect flight, reported in an article of ours whose final conclusions will be included here.

6. *Conclusions and physical applications* of ND:

a) The logical process of explanation leads us to conclusions and to ways in which the principles and theoretical laws which have been established can be applied. Nevertheless, creativity, research and synthesis sometimes follow a different path. This is what has happened in this study, so that this chapter corresponds, at least in part, to a series of experimental facts that led to the theoretical analysis of the principles and laws which govern them.

The *laws of conservation* in CD account for the majority of common processes, at least with sufficient approximation (for example: the movement of planets and their satellites) and other factors such as friction, viscosity, turbulence, etc., disguise the problem when the effects deduced from the preceding theoretical speculations should be taken into account. In our opinion this is the reason why the *Three Fundamental Laws* of Dynamics that we have expounded here were not formulated much earlier.

Aristotelian and Thomist Metaphysics called for a greater consideration and appreciation of the qualitative aspects of the Cosmos –and in particular of Dynamics– which could only be supplied by asserting that the *essence* of things in themselves were accessible and objective. "Transcendental metaphysics"– which I would rather call pseudometaphysics– takes us away from the World and, as a result, only helps us to penetrate more deeply into the knowledge derived from laws and qualities which we already know, yet –strictly speaking– "solutions can be lost" if we do not take into account some qualities of the thing in itself, which do not necessarily have to provide us with models of reality based on immanent "a priori" ideas.

b) In one of our first recorded studies, we came to the conclusion –in a completely heuristic way and not without error, since we knew nothing at that time of ND– that it was possible to cheat the laws of conservation of *angular momentum* and *lineal momentum* in a closed, unbound system. In ND, as we mentioned earlier, it is easy to construct systems which do not conserve angular momentum; so as not to conserve the lineal momentum, as has already been pointed out, there must be *dissipation* of kinetic energy by *radiation* in order to *uncouple* the forces acting on the system; otherwise its resultant is null and this "propulsion without reaction" is impossible.

This made us think that there might be living beings in Nature whose movement would be based on the *Three Fundamental Laws* of ND. The most obvious answer is, we believe, in the flight of the majority of insects, whose wing beats reach very high frequencies, with an extremely low number of REYNOLDS, which excludes lift based on aerodynamics as we know it. In the next section we shall cite some examples and assertions on this matter, taken from the most recently published studies.

c) In the diminutive insect *Haplothrips verbasci*, it can be observed that its two pairs of "wings" are nothing more than beating bars, approximately elliptic, with extremely fine and very flexible cilia, which cannot act as a surface for lift but must rather serve –in our opinion– to avoid air resistance by making the wing-bars more effective; the extremely rapid oscillation of the wing-bars would be less efficient if turbulence were produced. In the section on "discussion and suggestions" of one of these studies it is asserted: "Ignorance of the details about the mechanism of flight, at such a low number of REYNOLDS, points out the need for extensive observation, during flight, in order to determine the movement of the wing-bars and the cilia, and also the need for further study of these details with the electronic microscope, and also for measurements designed to determine the physical properties of the group of cilia..." Another study ends with the following words: "therefore, it must be concluded that there is little reliable information about the aerodynamic forces generated by wing beating and that the problem must be studied further". And in the publication "Scientific American", an article about unusual lift in certain insects, asserts: "The most important aspect, (the lift of) those insects and other flying creatures which I have discussed, depends largely on aerodynamic effects which are not stationary, and hitherto unknown, which for them are useful and not a hindrance, as they would be for man-made aeroplanes".

Clearly there is still a great deal of ignorance about insect flight and lift. If what has been expounded here and the experimental tests which were carried out are not mistaken, the explanation is clear and simple in the framework of ND put forward here: they would fly even in the absence of atmosphere or, at least, a good part of their lift and manoeuvrability is derived from forces, which do not exist in CD, but are dealt with in ND; air acts fundamentally to make respiration possible.

Nota bene:

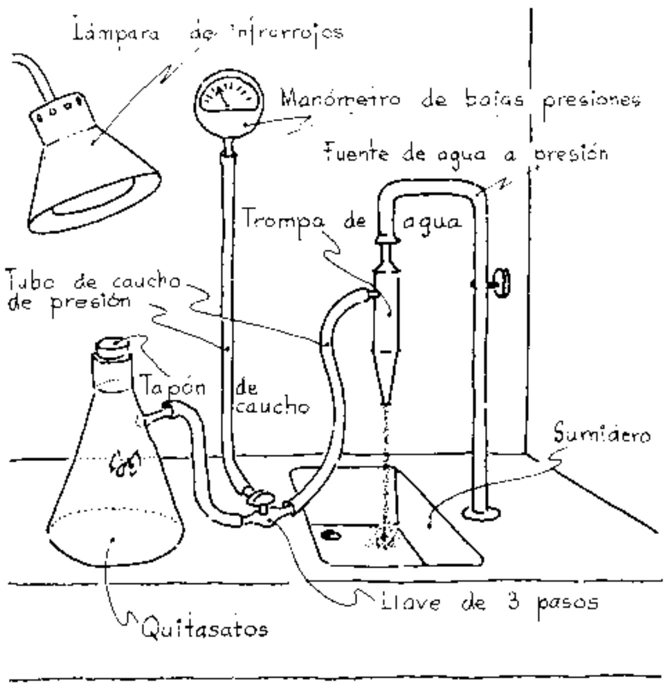
This study is, as pointed out in the Introduction, a second, revised edition of the 1976 publication. The most recent investigation on the subject of insect flight has progressed very little since 1975. We may point out here that in May 1977, after this article was published, tests were carried out on insects (Hymenoptera: *Bombus terrestris* and Diptera: *Calliphora vomitoria*) which were made to fly in a rarefied atmosphere (*13 mb*, equivalent to *98.7%* of normal atmospheric pressure: *1013 mb*). This experiment has been repeated several times since then. See our small article: *The flight of the bumblebee*, in "Investigación y Ciencia", February 1986, page 41.

An interesting article appears in the magazine "Nature", Vol. 344, 5 April 1990: *Unconventional aerodynamics* by ROLAND ENNOS, who gives a clear explanation of the problems of the most recent investigation. By way of illustration we have selected some extracts: "More evidence has appeared showing that insects fly by mechanisms quite unlike those used by aeroplanes and helicopters. ZANKER and GOTZ have measured the instantaneous forces produced by tethered *Drosophila melanogaster* flies and find that they cannot be explained by conventional aerodynamic theory. The forces are also evidence that these flies have unusual methods for producing lift... Studies over the past twenty years of the aerodynamics of insects in free flight have usually concluded that the forces resulting from a conventional lift mechanism would not be adequate to support or propel the insect, and this has been verified by the results of ZANKER and GOTZ..." and he finishes the article by saying: "Their results have two important implications. Firstly, it is clear that to solve the problem of how insects control their flight will be extremely difficult; even if we discover exactly how the large numbers of direct flight muscles control the fine details of wing movement, we will not be able to solve this problem until we have a better understanding of unsteady aerodynamics. Secondly, studies of the aerofoil aerodynamics in unsteady motion are urgently needed. Such investigation might not only clarify how animals fly, but would help us to improve our own aerodynamic designs; insects and birds are, after all, far more manoeuvrable than helicopters and aeroplanes."

d) ***The flight of the bumblebee.*** An article published in "Investigación y Ciencia", February 1986. This study is transcribed in full here below, together with the corresponding illustration (see Fig. 3):
SIKORSKY, the famous aeronautic designer, ordered this notice to be hung up in the lobby of his technical office: "the bumblebee, according to our engineers' calculations, cannot fly at all, but the bumblebee does not know this and flies". There are quite a number of studies about insect flight and all of them come up against enormous difficulties when they try to explain the mechanisms of lift through the dynamics of stationary fluids. Let us take a look at some examples.

TORKEL WEISS-FOGH wrote eleven years ago (in 1975) in *Scientific American* that: "the most important aspect (lift) of these insects and other flying creatures depends largely on aerodynamic effects which are not stationary, and hitherto unknown, which for them are useful and not a hindrance as they would be for man-made aeroplanes". In another study, on the subject of *Haplothrips verbasci,* ARNOLD M. KUETHE said something similar: "Ignorance of the details about the mechanism of flight, at such a low number of REYNOLDS, shows the need for extensive observations during flight in order to determine the movement of the wing-bars and of the cilia and, likewise, the need to penetrate more deeply in the study of these details using the electronic microscope, and also measurements designed to determine the properties of the group of cilia..."
We could add a great deal more evidence. The reader will find the problem dealt with clearly in the article by JOEL G. KINGSOLVER published in these same pages about the engineering of butterflies (October 1985). Amongst other things he described the difficulties found in complex insect flight, many of them insuperable, having recourse once more to TORKEL WEIS-FOGH's hypotheses.

For some years I have been investigating, empirically and theoretically, a new approach to dynamics of which Classical Dynamics would be a restricted part. Amongst other things it opens up the possibility that propulsion and lift exist even in the absence of atmosphere. How can insect flight be explained, from the dynamic point of view? Evidently it is not reasonable in the framework of Newtonian dynamics in which the conservation of lineal momentum, in an isolated system, excludes this type of lift and propulsion.



Vuelo del insecto en el vacío. Montaje del experimento.

(Fig.3)

In the field of cosmology the insufficiencies of Newtonian mechanical theories in their fundamental axioms were detected many years ago. Thus, the "first principle" asserts that an isolated material point (or system) follows a straight trajectory with a constant velocity; but the movement must be related to some inertial coordinated axes, external to the particle (or system) in question, which means that the isolation which is postulated is questionable, since it leads us to the contradiction that an isolated system has the property of not being isolated. This is the "weakest point of the magnificent edifice of Newtonian mechanics" (P. HOENEN, 1948). This *First Principle* must be rectified asserting that *there are not inertially isolated systems*.

With this new starting point, together with the axiom of energy conservation, this new dynamics began to take form beginning with the simplest case in which the potential energy is conservative, to generalize it, in a second step, to the non-conservative case. It leads us to the surprising result that in addition to the Newtonian forces of inertia, which only consist of the accelerations of particles and their respective masses, there are in fact other forces of inertia –hitherto unknown– which also include the velocity of particles, whose mass may behave as non-constant in the non-conservative case. These forces are isomorphic with "LORENTZ's forces" of electromagnetism, whose origin is purely empirical.

In the conservative case, the particle is affected by only one other force in addition to the classical ones: we have called it the *force of drag,* which is superimposed on the Newtonian one and is normal to the trajectory; it has the quality of changing sign when the physical point reverses the sense in which it is moving on the trajectory. We have an example in HALLEY's comet, which could be asymmetric when it passes through the perihelion, that is to say, the ingoing arc might not be identical to the outgoing one.

Passing on to empirical observation, we can use the bumblebee, *Bombus terrestris*, as an experimental source. The equipment I used to observe the "abnormal" lift of the insect in a vacuum consisted of a vacuum pump, a glass container, a triple stopcock and a pressure gauge (see the adjoining illustration). The vacuum pump must be one of the kind known as "water trunk", used as a filter in chemistry laboratories. No other kind of pump must be used for a very simple reason: it is vital to maintain the partial pressure of the water vapour at room temperature, so that the insect does not swell up or become otherwise deformed, as would happen if we used a different type of pump, even if the vacuum obtained were greater. Moreover, it is so quick and effective that the insect remains active in the vacuum for a maximum of one or two minutes. At a room temperature of *15 degrees* CELSIUS, a vacuum of *10 tor (13 mb)* is obtained, which compared with the normal value of atmospheric pressure *(1013 mb)* implies a vacuum of *98.7%* .

A transparent glass container of *1000 cubic centimetres* is used to hold the insect, closed hermetically with a rubber stopper and an outlet in the side to which the pressure tube, also rubber, is attached in order to cause the vacuum at the right moment. Larger containers should not be used in order for the emptying time to be minimal –about ten seconds– thereby allowing a maximum period of observation. The insect is introduced through the opening in the top which is then hermetically sealed.

Valves, or triple stopcocks, of this kind are very simple and cheap, made of glass; it is inserted into the pressure tube, to connect the vacuum pump to the glass container. This valve enables us to re-establish atmospheric pressure in the container, after having produced the vacuum, without it being necessary to disconnect the pump, and to maintain the vacuum indefinitely once it has been obtained. It also serves to check the level of vacuum that has been produced, by means of a pressure gauge. On the question of low pressure gauges, the mercury ones are very reliable and also digital precision pressure gauges.

It is well known that insects activate their flight capacity if they reach a suitable temperature. (It would be a good idea to place a "flexi" lamp near the container for illumination and also to provide sufficient heat for radiation.)

The observational results are surprising: for one or two minutes the insect continues flying, or takes off in flight, without any perceptible difference from flight at normal atmospheric pressure, even when hovering. The insect's legs are in the habitual position for flight, that is, gathered up and folded backwards.

The wing beat frequency is a characteristic of each insect which varies between very narrow limits in each species: around *300 hertz* for the bumblebee and *150 hertz* for the fly. Lift has an approximately lineal variation with the fluid density, so that flight in these conditions if we wish to explain it in terms of aerodynamics– would mean that the insect is capable of lifting a weight which is more than a hundred times greater than its own in normal atmospheric pressure; which does not seem scientifically acceptable.

In the case of insect flight the problem is generally not conservative and in this New Dynamics –which we have presented generically at the beginning of this article– there appear forces, which were hitherto unknown and responsible for lift and propulsion (without air being needed) which allow the empirical fact which we are putting forward to be explained. This is because in this new dynamic approach the laws of conservation of lineal momentum and angular momentum do not generally apply.

Classical dynamics is still perfectly applicable to those cases in which the system behaves *as if it were* inertially isolated, because of symmetries, zero tangential acceleration, circular orbit, etc., or else the new forces are negligible with regard to those which result exclusively from the masses and accelerations of the particles.

Thermodynamic *irreversibility*, the "strange and troublesome second principle" (J. MERLEAU-PONTY) which is incompatible with classical dynamics (MISRA-POINCARE theorem), is clearly shown to be corollary to the new dynamic approach, as is the particle-wave dualism. MAXWELL's equations of electromagnetism are deduced as a particular limit case of this ND. It must be noted that D. W. SCIAMA in 1953, FELIX TISSERAND eighty years earlier and, more recently, BRANS and DICKE all attempted an inverse process: to construct a theory of gravitation which was isomorphic with MAXWELL's electromagnetism.

e) DESTRUCTION AND CREATION OF ANGULAR MOMENTUM with respect to a VERTICAL AXIS OF ROTATION:

MACHINE A. *"destroys" angular momentum.*

This machine is compound of a steering wheel of mass M that turns around a vertical axis, with minimum friction. I n the same axis direction is mounted an elastic iron strap of *200 mm* length, *2 mm* width and *0,5 mm* of thickness that can oscillate in the vertical plane and rotates with the steering wheel. To its end a small mass $m<<M$ is fixed that oscillates with the iron strap, and remains in the rotation axis when it does not oscillate and the steering wheel is at rest. (See the machine scheme and the corresponding photos in following pages)

In CD it is necessary the conservation of *angular momentum*, referred to the vertical spin axis, when m is in this axis with initial angular speed ω_o . If m separates of the axis a distance r , the speed of rotation will be reduced so that the following relation is satisfied:

$$I_r\omega_r = I_0\omega_0 \tag{2}$$

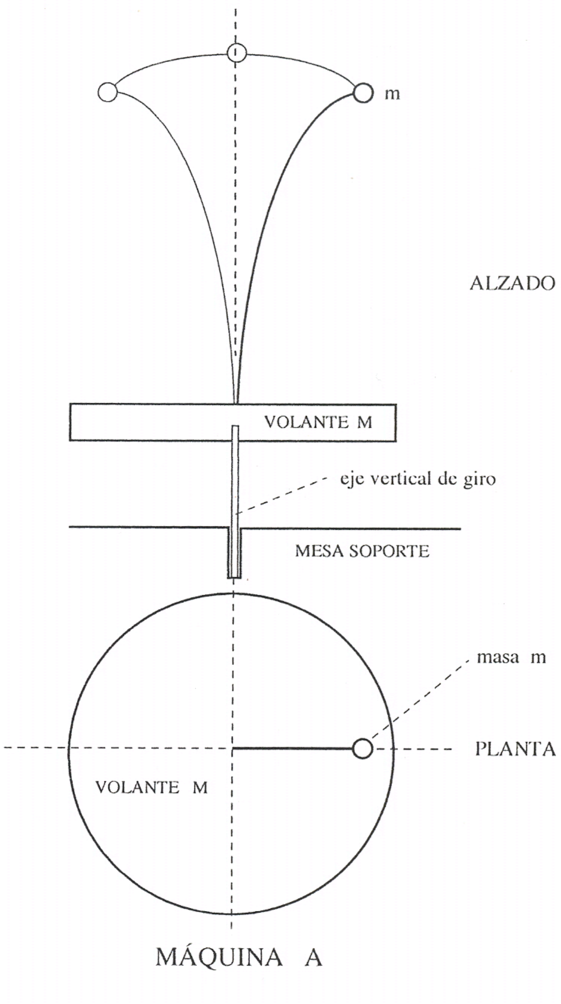
Being I_o the *inertia momentum* of the steering wheel M and ω_o the initial angular speed (m is assimilated to a material point); I_r is the *total inertia momentum* when, during the oscillation, mass m is detached a distance r from the axis. Its value is expressed by:

$$I_r = I_0 + mr^2$$

t is therefore $I_0 < I_r$ and by (2) it must be:

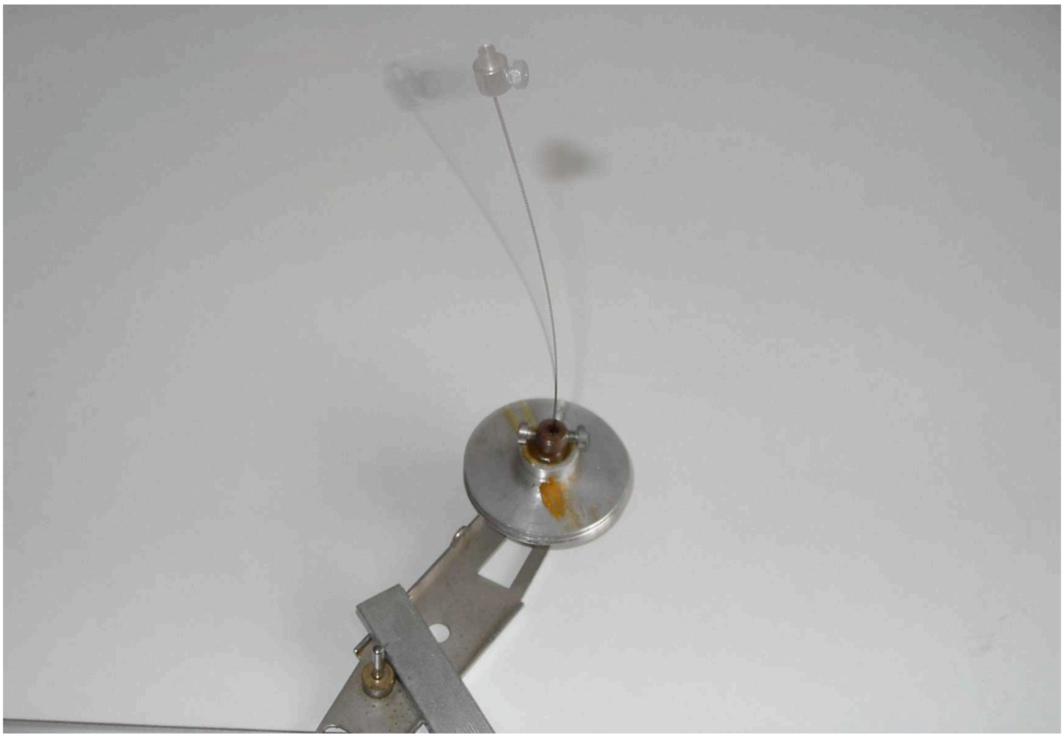
$$\omega_0 > \omega_r$$

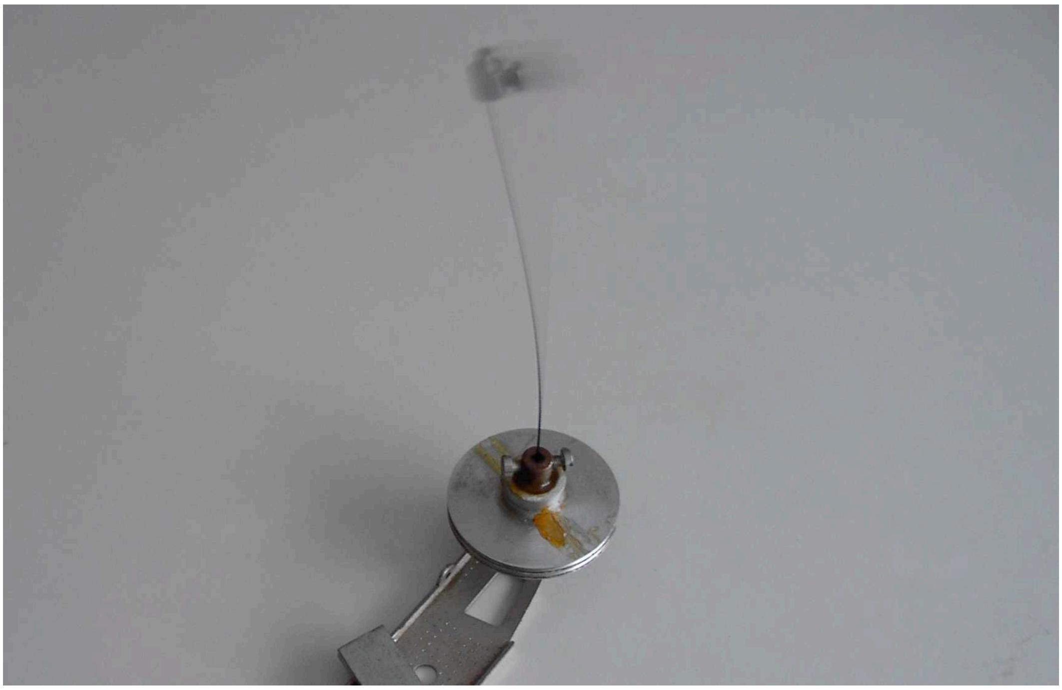
When, due to the elasticity of iron strap, it happens that m pass again through its position in the spin axis, the angular velocity will be ω_o , by the conservation of the *initial angular momentum,* and so on in each oscillation. *But this is not what is observed,* because when m leaves their unstable starting point, in the spin axis, the oscillations become important by the action of the centrifugal force on m , and the steering wheel stops quickly –in three or four turns– and the total initial kinetic energy of the steering wheel has been transformed into oscillating energy of the iron strap and mass m . The *initial angular momentum,* with respect to the spin axis, that must be conserved, has disappeared; this machine ***"destroys" angular momentum,*** against the exigencies of the CD , nevertheless this fact is perfectly coherent within the framework of the ND..



SCHEME OF MACHINE A

PICTURES OF MACHINE A.



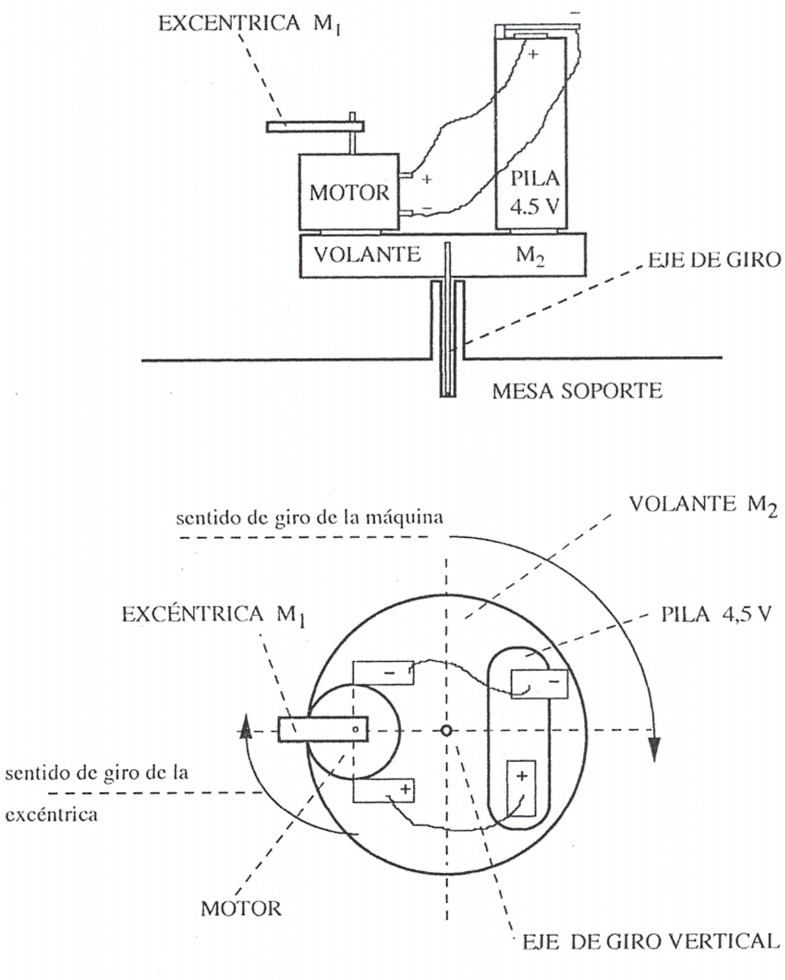


PICTURES OF MACHINE A.

MACHINE B. ***"Destroys"*** **and** ***"creates" angular momentum .***

This machine is formed by a steering wheel of mass M that turns around a vertical axis fixed in support-basis (see the following scheme and photos of this device).

An small *electric motor* –whose axis is parallel to the wheel axis –is installed in it with a *battery* of *4.5 V ;* their masses are included in *M.* The motor turns a small eccentric mass $m<< M$ with approximate speed of 2000 *tpm* (see pictures below). It is noted that the total mass *M+m* rotates around the vertical axis in the *same direction* as the motor rotation until reaching constant speed; increasing and decreasing with the motor speed. If external driving forces are applied to increase their rotation speed, the system reacts to decline it, and if forced to decrease, then reacts increasing it, until getting, in both cases, constant rotation. It should be noted that the little friction with the fixed axis does not explain this fact because, as already stated, the turning sense of the wheel and that of the eccentric mass *m are the same.* Therefore, *conservation of angular momentum*, which is "created" or "destroyed" until the steady state, is ***impossible***..



MÁQUINA B

SCHEME OF MACHINE B

PICTURES OF MACHINE **B**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f) LINEAL PROPULSION WITHOUT REACTION *(LPWR).*

1 In the environment of the New Dynamics (ND) that have presented here, and that it comes to enlarge the frame of the Newtonian or Classic (CD), it is possible that the *laws of conservation of the lineal momentum* and of *the angular momentum* do not fulfil in an isolated system, as demands the CD. In this ND the force that acts on a material particle, of mass m, is no longer only due to the acceleration that suffers in an inertial frame, but other forces intervene up to now not taken in consideration. Without going down to details, neither theoretical considerations that it is not here our purpose, the *total force* $\boldsymbol{F}$ that acts on a particle or material point that describes a generic trajectory, with *velocity* $\boldsymbol{v}$*, acceleration* $\boldsymbol{a}$, (and taking in account the corresponding *evolute* linked with the trajectory through the curvature radius R) it is given by:

$$\boldsymbol{F} = [m\boldsymbol{a} + (1/2)(dm/dt)v\boldsymbol{s} - mv(dv/dt)/(dR/dt)\boldsymbol{n} - (1/2)(mv^2/R)\boldsymbol{n}] \qquad (3)$$

in which the trajectory is referred to a FRENET trihedron, whose *versors* are $\boldsymbol{s}$, $\boldsymbol{n}$, $\boldsymbol{b}$, being $\boldsymbol{b} = \boldsymbol{s} \times \boldsymbol{n}$. As it can be observed in (3) the mass m no longer behaves as a *constant,* it varies with the *time* in general:

$$m = m(t) \qquad (4)$$

2. In view of the expression (4), even in the case that the trajectories are right, it is possible the non conservation of the *lineal momentum:*

$$\boldsymbol{p} = \sum m_i \boldsymbol{v}_i$$

in an *isolated system;* because, besides the forces of acceleration over each m_i, there exists the force:

$$(1/2)(dm_i/dt)\boldsymbol{v}_i = (1/2)(dm_i/dt)v_i\boldsymbol{s}_i \qquad (\boldsymbol{s}_i \text{ versor}) \qquad (5)$$

and doing things in an appropriate way, it can allow the *non conservation* of $\boldsymbol{p}$ demanded by CD. For simplicity we will centre ourselves in this simple case in order to explain the working of ***Lineal Propulsion Without Reaction*** **(LPWR)** that will be presented later.

In the precedent detailed theoretical works it is exposed how to reach the conclusion of being $m = m(t)$ and how to attain the general expression (44), etc.

3. In an *isolated system* formed for only *two bodies* in rectilinear interaction, although the forces (5) can exist, their *resultant is null* and it is impossible the *"uncoupling"*. For this aim it is necessary the interaction of *three or more bodies*.

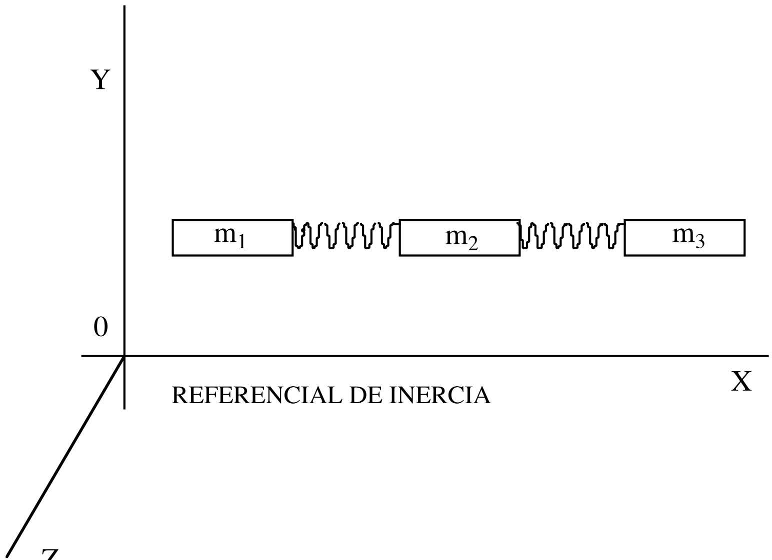


FIG. 1

Let us suppose, for bigger simplicity that is three bodies (material points) linked by means of interactions *(potentials)* that all act on the same straight line (see outline in the fig. 1); in which the "springs" that unite the masses m_i express the potential energy U_{12} , U_{23} that depend on the distances x_{12} , x_{23}, among the masses of the system (in a frame of inertia OXYZ). Under these conditions the *subsystem* formed by each mass m_i has a potential energy U_i that depends on its *position* x_i and of the *time* t, because the other two masses evolve simultaneously and they cause this temporary variation of their potential. In these circumstances can be write:

$$U = U_{12}(x_1,x_2) + U_{23}(x_2,x_3) = U_1(x_1,t) + U_2(x_2,t) + U_3(x_3,t) \qquad (6)$$

It interests to us this last individualized form [right-hand term of (6)] of expressing the potential energy, while in AD the first one is used [first member of (6)].

In our ND these individualized variations, are the cause that m_i can be time dependent:

$$m_i = m_i(t)$$

therefore on each mass m_i my act the additional force:

$$(1/2)(dm_i/dt)v_i\boldsymbol{s}_i \qquad (7)$$

described in (46) (being $\boldsymbol{s}_i$ the *versor* according to OX_i).

According to this, if the forces (7) are reached, it seems that the problem of the PLSR would be solved; however it is not so, because the experimental tests carried out (more than twenty) they teach us the *"coupling"* of forces (7) . Consequently we have

$$\sum(1/2)(dm_i/dt)v_i\boldsymbol{s}_i = 0 \qquad (8)$$

Consequently lineal propulsion is not observed in an *isolated system* without *energy dissipation*. However this becomes patent when *energy dissipation* exists between *two* of the masses of the system, for example between m_2 and m_3, and there it is not between m_1, m_3, neither between m_1, m_2. It is enough observing (8) to notice that these forces depend on the *velocity* $\boldsymbol{v}_i$ of each particle. The *dissipation by friction* (or similar phenomenon) makes vary the velocities of the two masses over that it acts directly; for example: the *friction* between m_1 and m_2, but it doesn't vary the velocity of third mass m_3 (or it occurs in a completely different way) and then the *"coupling*" disappears. It is possible to write

$$\sum(1/2)(dm_i/dt)v_i\boldsymbol{s}_i \neq 0 \qquad (9)$$

Evidently, the action of these forces (9), additional to the classics, it is the cause that the *lineal momentum* $\boldsymbol{p} = \sum m_i v_i \boldsymbol{s}_i$, is not conserved, in spite of being an *isolated system.*

4. In the Nature they exist "machines" propelled without reaction, by the forces (44), up to now not taken in consideration because they were ignored. We refer primarily to the flight of the insects, up to now practically inexplicable. –in most of the cases at least– based on the well known dynamics of fluids. We have made fly insects *("Bombus terrestris", "Calliphora vomitoria", etc.)* in the vacuum *(13 mb)* (1.976-77). Their flight is perfectly regular and without differences regarding to that observed at normal atmospheric pressure *(1.013 mb)*. For to do this experience with the insect in flying conditions it is necessary to conserve the partial *water vapour pressure* at room temperature (15º C approx.), otherwise the insect is deformed because it "boils" (at this temperature) and it cannot fly. It supposes a vacuum of the order of 98,7% that doesn't allow the sustentation based on aerodynamic forces.

We make reference to these tests because they had been the incentive in the work of to invent and construct machines doing the same thing. Otherwise we would probably have abandoned the task. In order of doing it has been necessary, in the first place, to elaborate the theoretical frame that allowed us to arrive to the expression (3); in second place to realize the existence of the *"coupling"* and find the way to undo it, by means of partial *dissipation* of the available energy. This work has lasted twelve years. The most effective lineal propellers are the recent ones.

This succinct description is very related with the *Thermodynamical Second Principle:* "it is impossible to get work without "losing" in the "radiator" part of the available energy ".

5. Up to 1990 the built machines were based on the interaction of *three masses (PLWR –3)* or f*our masses (PLWR. – 4)*, moved by coils, fed by *ac 40 V.* The device described here works by means of vibration (see fig. 2 of the present study) that is produced by the action of a small mass,

m_1 which rotates in eccentric way and moved by a motor of $3.\!-\,8\ V$, fed by a battery of $3\ V$ (alkaline or rechargeable) mounted on a small platform whose total mass is m_2 *(motor + battery + platform).* The mass m_2 slips, with energy dissipation by friction, over a third mass m_3 (formed by an horizontal board) by means of two supports (see fig. 2), made of steel wire of *0.5 mm ,* in form of "U" subject to platform m_2 . The "U" horizontal part slips on m_3 , while its subjection parts form with vertical an approximate angle of 15^o *grad*. (see fig. 2). The experience has shown us that this angle is the good one.

The *PLWR* by vibration that we present here *(PLWR–vib.)* is formed by a group of *three masses* and it is propelled in the sense indicated by the inclination *(15º grad.)* of the two supports (see fig. 2). To check that appreciable reaction doesn't exist, m_3 has been hung at the roof by means of *4* nylon threads (of *1.5 m* of longitude) forming with the suspended board a deformable parallelogram that conserves the horizontal position. The vibrant system $m_1 + m_2$, moves on m_3 with a speed that reached *40 m/minute,* while the last one remains immobile In this sense the effectiveness of this machine is very superior to that of the precedent models: *PLWR.–3 , PLSR.–4 ,* being its construction much more simpler.

The two "U" steel supports can be substituted by other equivalent in form of "toothbrush" whose fibre have an inclination of 15^o *grad*. with vertical.

Some years ago appeared in the Spanish market toys that were propelled this way (by means of "brushes") without suspecting the propulsion without reaction described here. Actually they are not for sale.

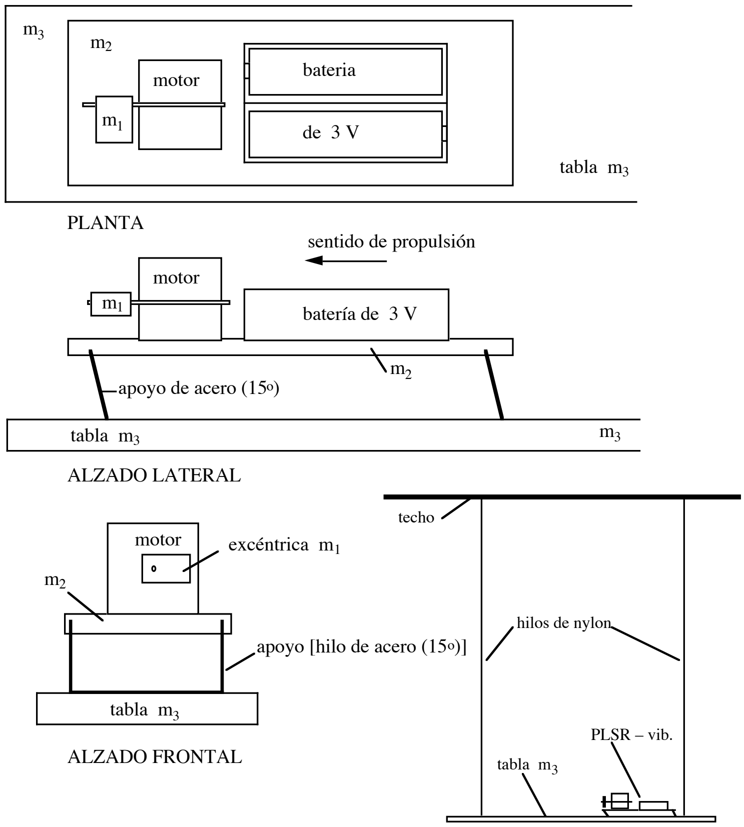
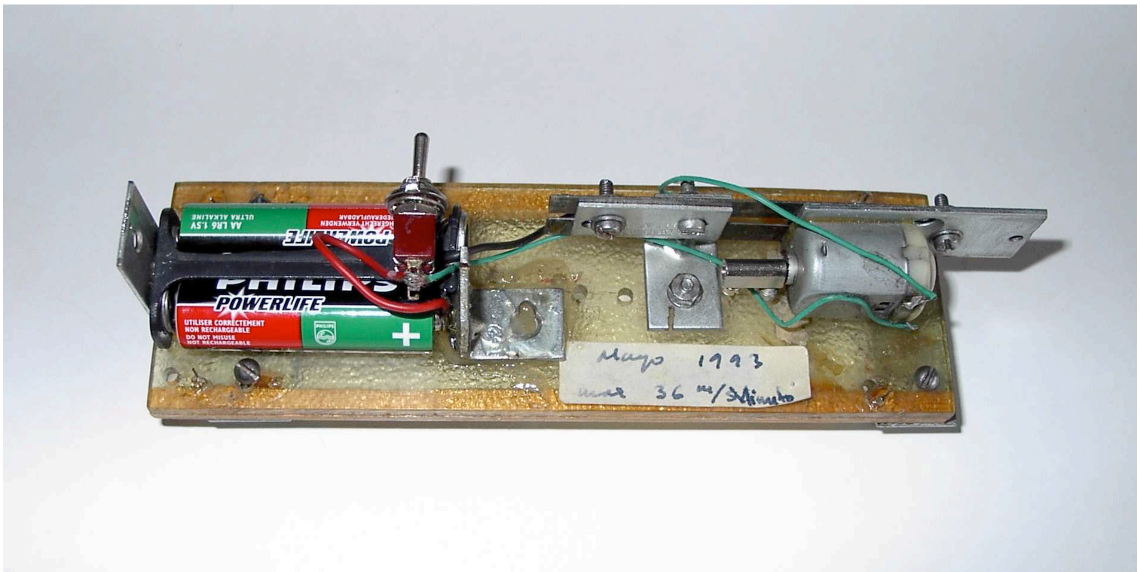
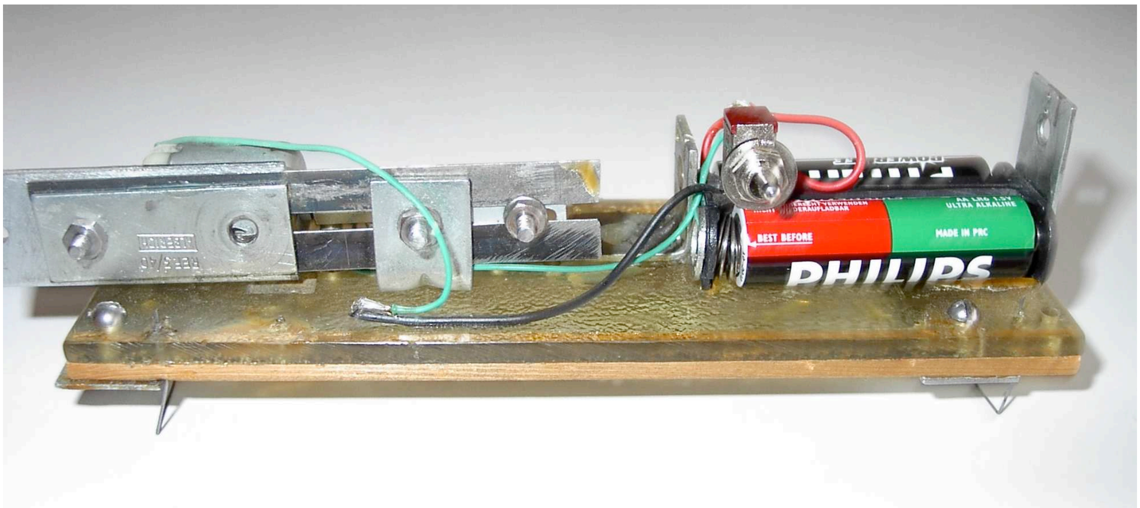


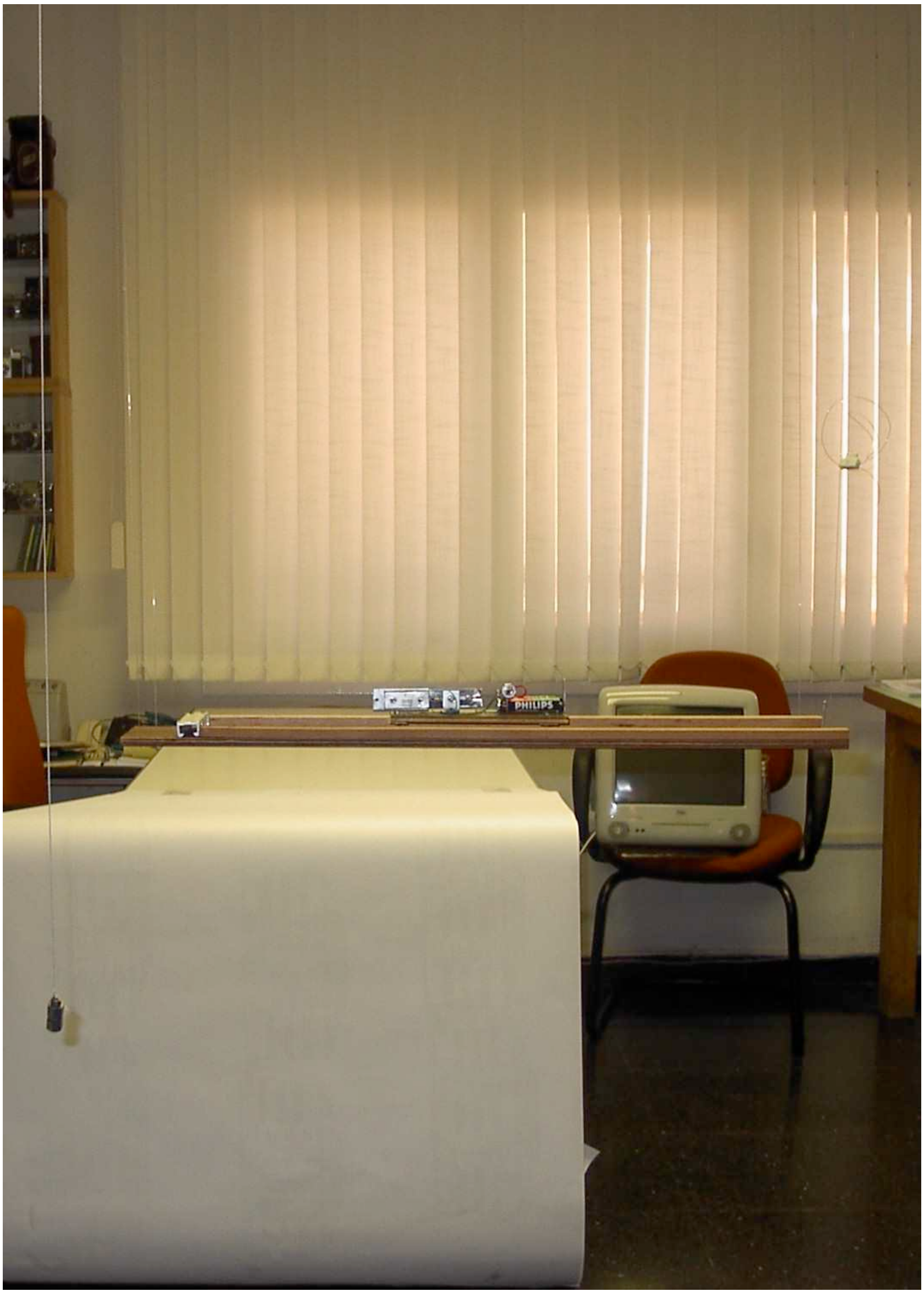
FIG. 2 ESQUEMA DEL PLSR – vib.

OUTLINE OF THE ***LPWR*** *(vibration)*

PICTURES OF THE ***LPWR*** *(Vibration)*







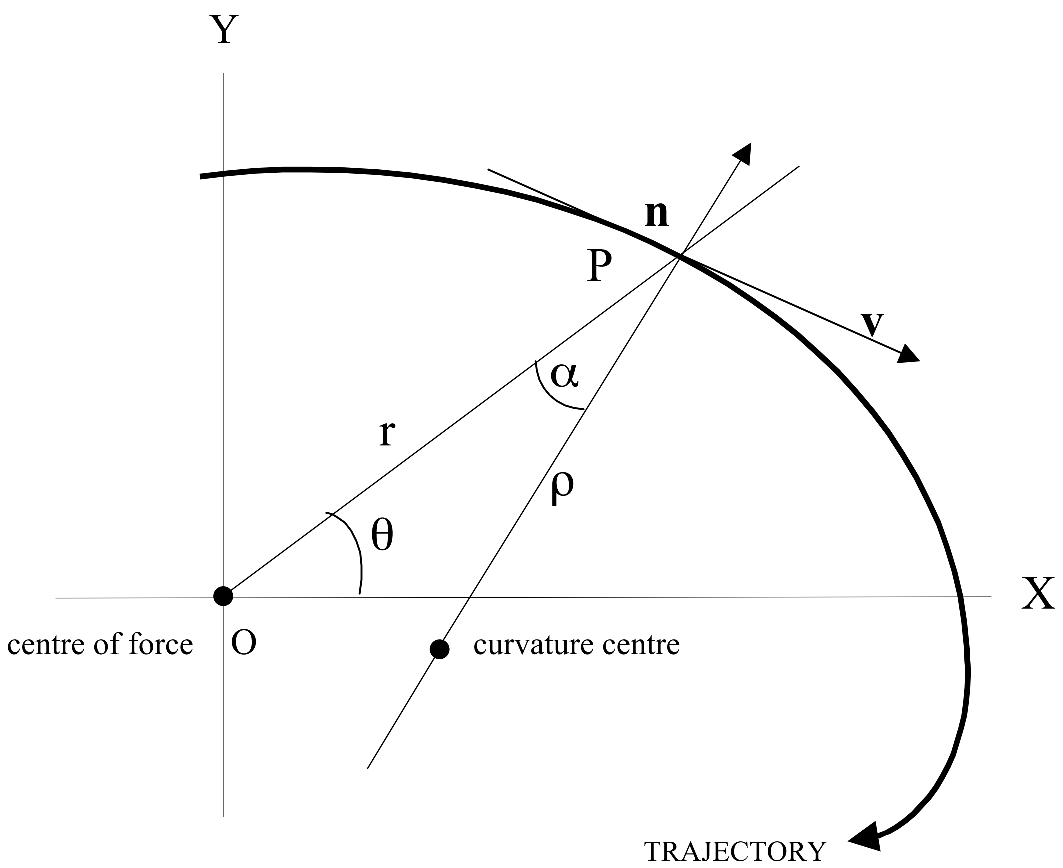
The initial rest position of the ***LPWR*** system with respect to the plumb–bob at links.

Oscillatory position of the system towards the link side. Distance of the system extreme border and the plumb–bob aprox 5 cm.

Oscillatory position of the system towards the right side. Distance of the system extreme border and the plumb–bob aprox 15 cm. Oscillation amplitude 15 – 5 = 10 cm.

g) THE PROBLEM OF *"two bodies"* IN THE ND

We study here the peculiar case of *two bodies* in interaction in the frame of the ND. We simplify the problem reducing it to the action of a *central force* on a material point of mass *m*. It is the case of the gravitation forces, of Coulomb forces, etc. We outline the problem with the hypothesis that the mass $m = Constant$ and we will expose that this is impossible, because even in this case of only *two bodies*, it should be $m = m(t)$. It is evident that the same thing will happen when three or more bodies are interacting. It is a plane trajectory travelled by a material point *m* with speed $\boldsymbol{v}$, acceleration $\boldsymbol{a}$, in *intrinsic coordinates*, being ρ the curvature radius. and $d\theta/dt$ the angular speed, while in *polar coordinates* r is the radius to the centre of force *0* , and $d\Theta/dt$ the angular speed (see figure).



In the ND the expression of the central force in polar coordinates (see **Chapter**. **IV, E** (41) p. 77) is given for:

$$\boldsymbol{F} = m(r\dot{\theta}^2 + r^2\dot{\theta}\frac{\ddot{\theta}}{\dot{r}} + \ddot{r})\hat{r} + \tfrac{1}{2}\frac{\dot{m}}{\dot{r}}(r^2\dot{\theta}^2 + \dot{r}^2)\hat{r} \tag{10}$$

And in the intrinsic inertial trihedron their expression is:

$$\boldsymbol{F} = m\boldsymbol{a} - mv\frac{\dot{v}}{\dot{\rho}}\hat{n} + \tfrac{1}{2}\dot{m}v\hat{s} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\hat{n}$$

We make the hypothesis of $m = constant$, in which case (in the precedent expressions) are annulled the terms in which *dm/dt* appears.. In ND being central the force, the acceleration won't be it. The module of $\boldsymbol{F}$ should be:

$$F = projection\ \ of\ \ \boldsymbol{a}\ over\ \ \boldsymbol{r} + projection\ of\ -mv\frac{\dot{v}}{\dot{\rho}}\hat{n}\ \ over\ \boldsymbol{r}$$

and in view of the figure we can write this expression:

$$F = -mr\dot{\theta}^2 + m\ddot{r} + (-mv\frac{\dot{v}}{\dot{\rho}}\cos\alpha)$$

that should be identical to the module of (10). And simplifying terms in this identification we have:

$$\boxed{2mr\dot{\theta}^2 + mr^2\dot{\theta}\frac{\ddot{\theta}}{\dot{r}} = -mv\frac{\dot{v}}{\dot{\rho}}\cos\alpha} \tag{12}$$

In the last one (12) we can observe that all the tangent trajectories in the point considered P had locally the same values for *m, r, dr/dt. dθ/dt,* $d^2\theta/dt^2$ *;* and consequently the same values for *v, dv/dt , α ,* and *curvature radius ρ* (notice that $v^2=\rho^2(d\Theta/dt)^2 = r^2(d\theta/dt)^2+(dr/dt)^2$ they don't have the same *dρ/dt*) . This way the things, the equality (12) won't be verified in general for the same central force $\boldsymbol{F}$. We reach the conclusion that the simplifying hypothesis of considering $m = constant$ is generally insufficient; it will be necessary to admit that even in this simple case of interaction between *two bodies,* and c*entral force,* the mass will vary with the *time:*

$$\boxed{m = m(t)}$$

This function *m(t)* it will depend on the type of trajectory: hyperbola, logarithmic spiral, exponential, etc. that will also be different when changing the motion sense in each case. The equality 12) will come to be:

$$\boxed{\begin{aligned} &2mr\dot{\theta}^2 + mr^2\dot{\theta}\frac{\ddot{\theta}}{\dot{r}} + \tfrac{1}{2}\dot{m}(\frac{r^2\dot{\theta}^2}{\dot{r}} + \dot{r}) = \\ &= -mv\frac{\dot{v}}{\dot{\rho}}\cos\alpha - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\cos\alpha + \tfrac{1}{2}\dot{m}v\,\text{sen}\,\alpha \end{aligned}} \tag{13}$$

And no longer inconvenience exists that equality (13) is verified, in each trajectory, by the action of a central force. in a point P each different trajectory will have different *dm/dt* and also different *dρ/dt* . changing its sing when the particle motion in the trajectory is *reversed*, causing the *trajectory* ***irreversibility*** (see pp. 54 and ss.).

When *m = m(t)* it is immediate that the kinetic energy, that depends only from the position if *m = constant* , now will be also *time dependent*. The same thing will happen with those energy potentials in whose expression the mass intervenes. For instance: the gravity potential in an isolated system without dissipation. The energy conservation will demand

$$T(P, t) + U(P, t) = constant \tag{14}$$

In which also *U = U(P, t)* if we suppose that *t* is *independent of the position* and not a *simple parameter*. It can happen that the *constant value* that appears in the expression of some potential energy, in fact it is not so, but from expression (14) it is *time dependent.* For example, in the elastic potential: $-Kx^2$, it will be *K = K(t)*.

THE FLIGHT OF THE HUMMING–BIRD

The sustentation, propulsion and manoeuvre of the Humming–bird are explained very easily on the basis of New Dynamics (ND), thanks to the presence of the *Supplementary Normal Acceleration* (SNA), that causes the *normal force* to the trajectory of the wing of mass *m* in its g. c. (See Fig. 1 in which the position of its end is indicated in successive time intervals).

$$\boldsymbol{F} = \mathrm{mv}\frac{\dot{\mathrm{v}}}{\dot{\rho}}\boldsymbol{n} = \mathrm{mv}\omega * \boldsymbol{n}$$

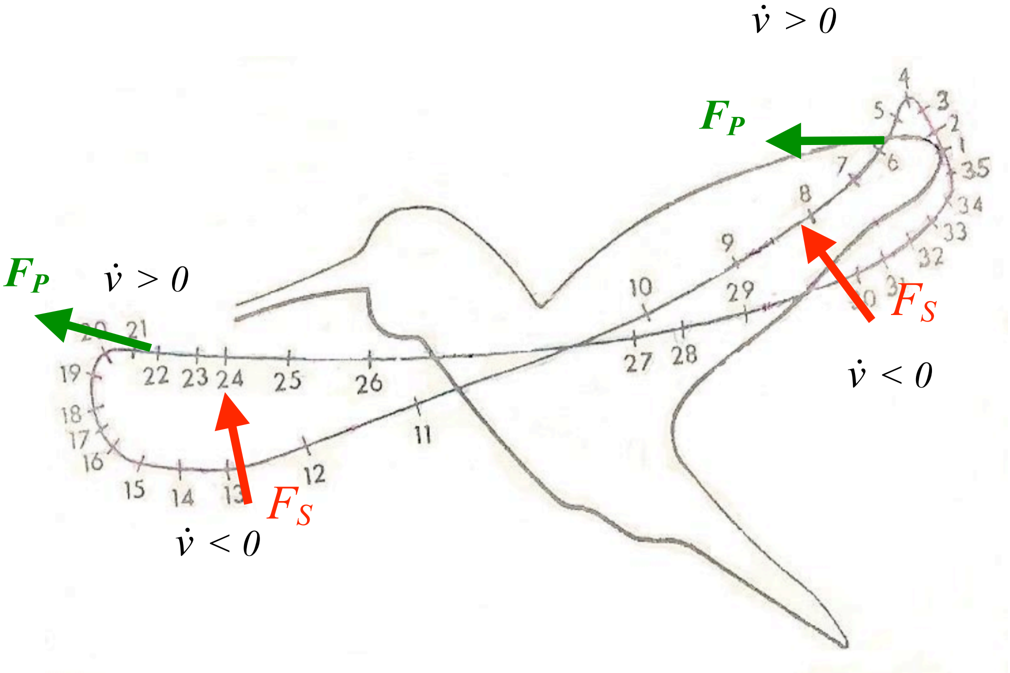


FIGURE 1[1]

[1] "Path of the wing tip of a hovering hummingbird (Stolpe and Zimmer. 1939).

According to which the *tangential acceleration* $\dot{v}$ is *positive* or *negative,* the sense of these forces is towards the *convexity* or the *concavity* of the trajectory. In the figure: $\boldsymbol{F_S}$ indicates sustentation, $\boldsymbol{F_P}$ propulsion and manoeuvre. The numbered points corresponds to equal time intervals, indicating also the warped direction of movement (in flat projection in the figure). The increasing the distance among them, means that the acceleration is positive, and negative on the contrary.

NOTE:

In order to facilitate the understanding we included the study of the *Supplementary Normal Acceleration* SNA, departure point of the ND, that is included at the end of these experimental tests.

EQUILIBRIUM OF THE BICYCLE

It is very difficult to explain the equilibrium of a cyclist (bicycle, motorcycle, children's scooter, etc.) based on the centrifugal forces of the CD that, if the movement is very slow, can solve the problem. When the speed is great the trajectory can practically be maintained straight, without difficulty, with almost imperceptible turns of the handlebars to right and left. In this case the radius of curvature ρ of the trajectory can be considered infinite and the preceding forces are null, and so the balance is without solving.

The movement is on a horizontal plane with the gravity force normal to the same. Everything referred to the FRENET's trihedral ***(s, n, b)*** in rest with respect to the inertial frame of reference OXYZ.

When turning the handlebar, very slightly if the speed is great, to maintain the balance, the system acquire a rotation energy:

$$E_{rot} = (1/2)I\omega^2 \qquad (1)$$

that is *absolute,* because the rotation $\boldsymbol{\omega}$ does not vary when changing of inertial frame of reference. Supposed speed v *constant* in this minimum turn, the kinetic energy $(1/2)mv^2$ must *lose* or *gain* the transferred energy E_{rot} (1) to the rotation according to which this one *increases* or *decreases;* but by the conservation of energy the unique possibility is that mass m *is not constant,* that is to say, increases or diminishes in an amount dm giving rise to the presence of the factor $dm/dt = \dot{m}$, positive or negative.

In the ND the *total force,* on mass m in movement (cyclist + bicycle) is given by the expression[2]:

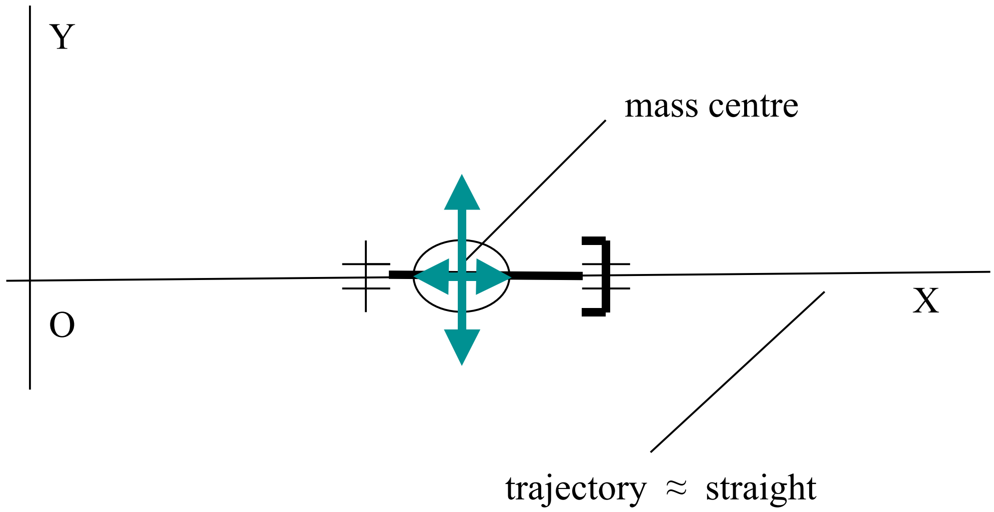
$$\boldsymbol{F} = m\dot{v}\boldsymbol{s} + \tfrac{1}{2}\dot{m}\boldsymbol{v} - m\frac{v^2}{\rho}\boldsymbol{n} - mv\frac{\dot{v}}{\dot{\rho}}\boldsymbol{n} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\boldsymbol{n} \qquad (2)$$

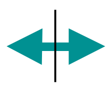
[2] *Vid.* JUAN RIUS–CAMPS, *Dinámica de Sistemas Mecánicos Irreversibles* . Ed. ORDIS. Barcelona. 2009.

Being constant speed $\boldsymbol{v}$, it is *null* the tangential acceleration $dv/dt = \dot{v} = 0$, In addition, when considering *infinite* the curvature radius ρ , (2) is reduced to:

$$\boldsymbol{F} = \tfrac{1}{2}\dot{m}\boldsymbol{v} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\boldsymbol{n} \qquad (3)$$

Being *dm/dt*, *positive* or *negative,* the first term of 3) is a force, that tends to *accelerate* or to *restrain* the moving body, whereas the second express a non-null force, *normal to the trajectory,* that acts to *right* and l*eft* of the same, preventing the fall of the cyclist (see SCHEME).





forces of *acceleration* and *braking*

equilibrium normal forces

SCHEME

NOTE:

In order to facilitate the understanding we included the study of the Normal Acceleration Additional SNA, departure point of the ND, that is added at the end of these experimental tests.

I. THE FARADAY DISK

This problem, according to some, violates the conservation of the angular momentum; others will explain it using the relativistic transformation, as Professor SERRA-VALLS[3] does. Many will remain satisfied applying to it the denomination of exceptional case.

Here the results of a *"New Dynamics (ND) of Irreversible Mechanical Systems"*[4] which is isomorphic with the Electromagnetism of MAXWELL-LORENTZ, will be used. We will study the case of a spiral in the symmetrical field of a magnet, located in the normal axis to the same by its centre. (see fig 1).

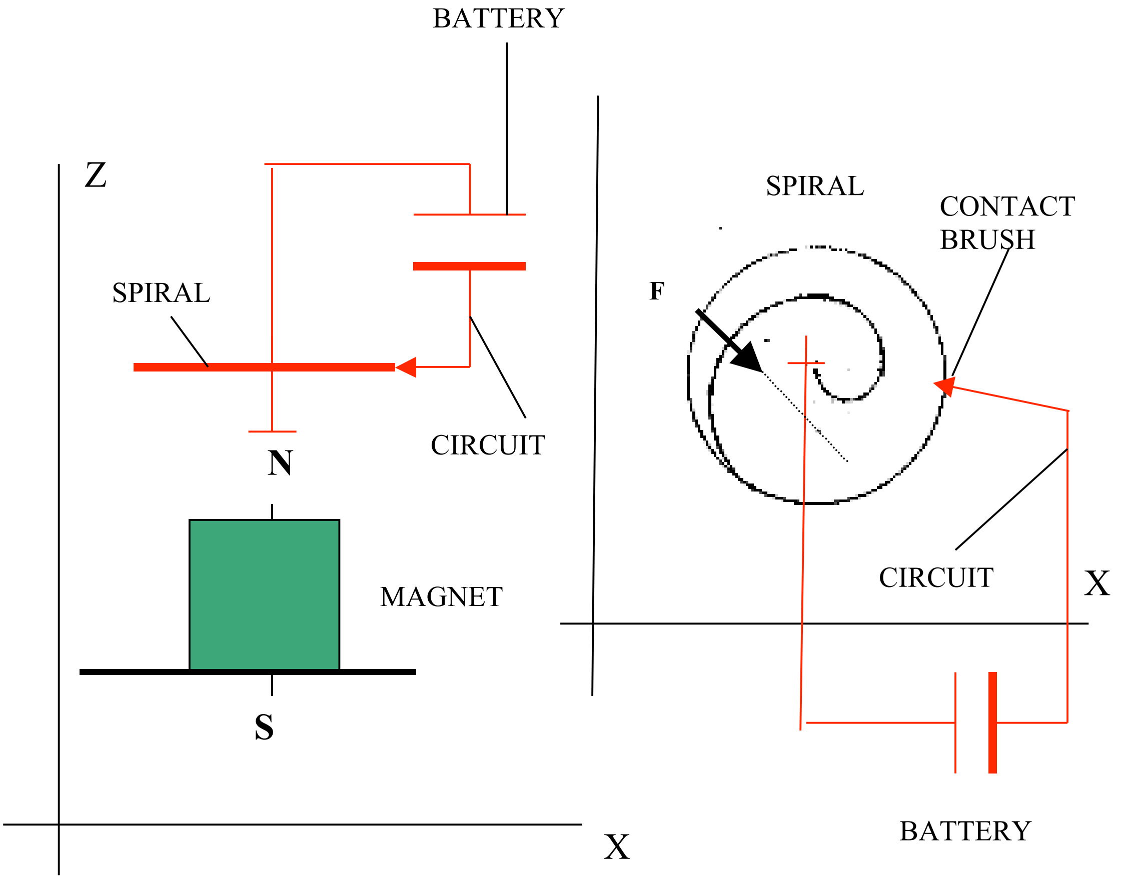


FIG. 1

[3] A SERRA–VALLS. *El motor turbo electrodinámico.* Ed. IVIC. Caracas. 2009.
[4] JOHN RIUS-CAMPS. *Los Fundamentos Cosmológicos de la Mecánica y las Leyes Fundamentales de la Dinámica*. Anuario Filosófico. Vol. IX. 1976. Universidad de Navarra.

In order to study the present problem we will apply the expression of the "LORENTZ Force" of Electromagnetism:

$$\boldsymbol{F_L} = q(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B}) \qquad (1)$$

Considering that does not exist the electric field and is only present the magnetic field $\boldsymbol{B}$ (external to the system), created by the cylindrical magnet. The force $\boldsymbol{F}$ that acts on a charge q, in an element of current of the conductor in spiral, is ***external to the system*** like $\boldsymbol{B}$, and will be normal to it in this point (see fig 1); the expression (1) is

$$\boldsymbol{F} = q(\boldsymbol{v} \times \boldsymbol{B}) \qquad (2)$$

The result of the addition of all forces $\boldsymbol{F}$, on a spiral conductor, will be an external pair that will cause its rotation. One reaches the immediate conclusion that the *angular momentum* in the turn of the FARADAY disc (spiral) *is not conserved.*

Classical Dynamics (CD) demands the conservation of the angular momentum and it is not possible to be applied to the present study. In the New Dynamics (ND) the same force $\boldsymbol{F}$, on a mass m and charge q, is given by the expression,

$$\boldsymbol{F} = m(\boldsymbol{v} \times \boldsymbol{\omega*}) \qquad (3)$$

With $\boldsymbol{\omega*} = (dv/dt)/(d\rho/dt)\boldsymbol{b}$ ($\boldsymbol{b}$ is the *versor* according to the *binormal* in the FRENET's frame). Since the referred rotations only have sense to a referential of inertia like the one of our system, and it is *external* to the same; it results that $\boldsymbol{\omega*}$, as the field $\boldsymbol{B}$, is *external* also. In addition, the force (2) changes sign with $\boldsymbol{v}$, that is to say, when the current sense is reversed; the same happens to the force (3) of the ND. Consequently, force $\boldsymbol{F}$, expressed mechanically (3), must agree with. its electromagnetic expression (2). Obviously the *angular momentum* is ***not conserved*** either here.

On the other hand the expression of the total force over the mass *m* in the ND is

$$\boldsymbol{F}_{total} = m(\boldsymbol{a} + \boldsymbol{v} \times \boldsymbol{\omega *}) \qquad (4)$$

being $\boldsymbol{a}$ the acceleration of m ; therefore, the "LORENTZ force" (1) is the electromagnetic expression of (4) . It is evident, also, the *isomorphism* between the **Electrodynamics** and the **ND**.

NOTES:

1. When the tangential acceleration dv/dt on m is *null,* and then $\boldsymbol{\omega *} = \boldsymbol{0}$ with $\boldsymbol{F} = \boldsymbol{0}$. This does not happen in our case, being variable the *moment of inertia* of the mass m that runs along the spiral. Also is $\boldsymbol{F} = \boldsymbol{0}$ when the spiral is reduced to a circumference.

Like has proved professor SERRA-VALLS[5], the logarithmic spiral, of constant 1 , is the most efficient.

2. In order to explain the conservation of the *angular momentum* some authors maintain that the *outer circuit,* formed by the battery and the conductors that connect with the axis and the periphery of the disc, constitutes the *stator,* whereas the *disc* would be the *rotor*[6]. The same doctor SERRA-VALLS has tested that after *blinding* the external circuit, the *disc* continues turning, and thus it would be necessary to affirm the *non-conservation of the angular momentum*, but this fact results incredible to him, and goes to the relativistic solution of the phenomenon. In the final section: **II. STUDY OF THE "FARADAY DISK**, is clearly expressed this blindage possibility.

3. In order to facilitate the understanding, see the study of the *Normal Supplementary Acceleration* (NSA), departure point of the ND, that is included in the next section.

[5] Doctor ALBERTO SERRA-VALLS, in his book *El Motor Turbo Electrodinámico y la Nueva Ley de Inducción* (Venezolan Institute of Scientific researches. 2009), presents the substitution of the disc by a conductor in the form of logarithmic spiral located in the same plane and centre. Also the magnet can be replaced by the magnetic field created by the current in the spiral.
[6] *Ibidem.*

II. ESTUDY OF THE "FARADAY DISK"

The problem can be simplified replacing the FARADAY DISK by a horizontal *radial rotating bar* around a vertical *conductor axis*. This would be the *rotor*. The *stator* is formed by a *circular conductor* and a second *radial bar*, both fixed to an inertial frame **XYZ**. The *battery* is in contact with the *vertical axis-conductor.* A *contact–brush mechanism* at the end of the first bar, closes the circuit with the *circular conductor* (see the figures **A** and **B**)

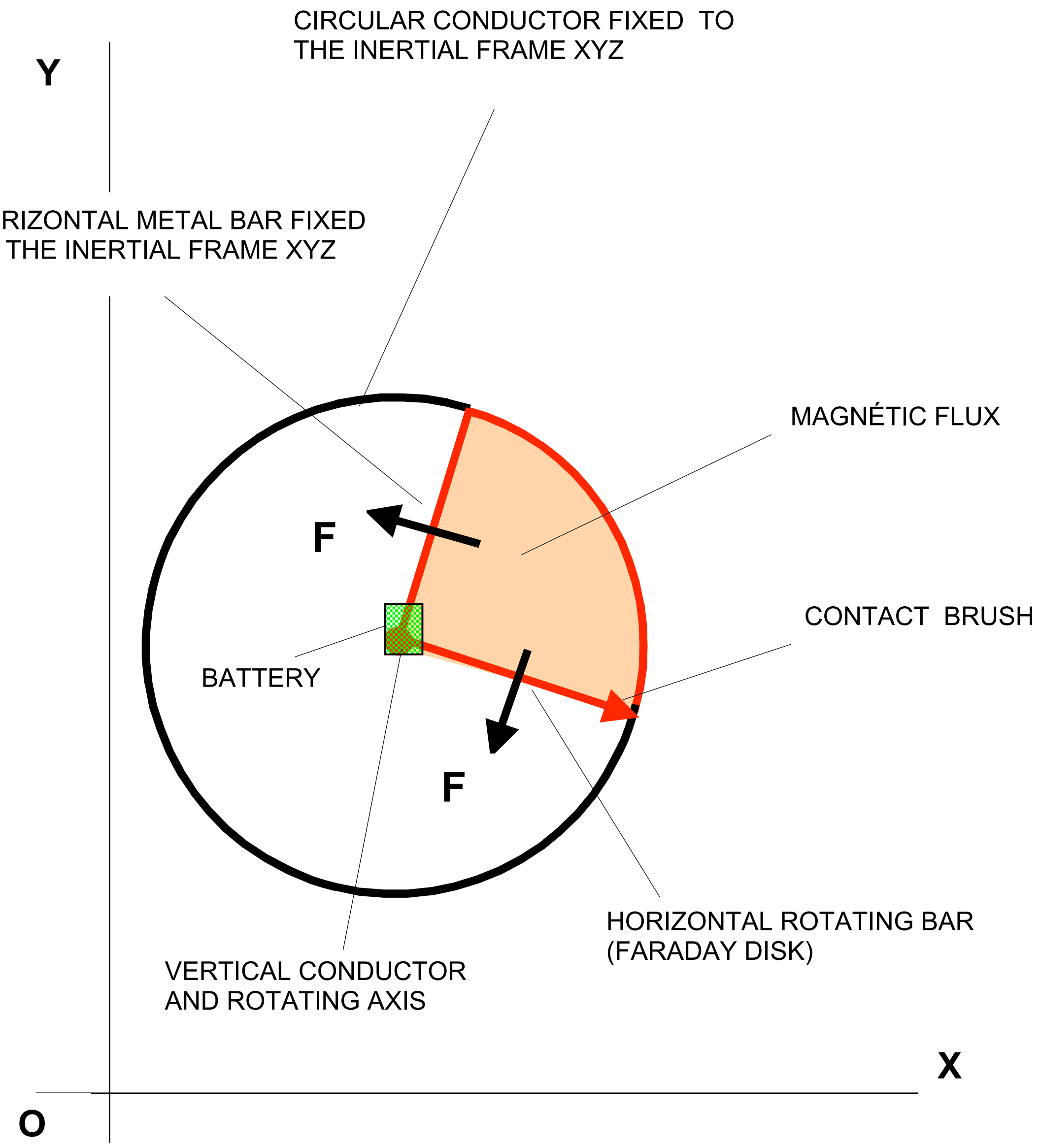


FIG. A (horizontal projection)

The magnet is a vertical and symmetrical cylinder, fixed with respect to the inertial frame **XYZ.**

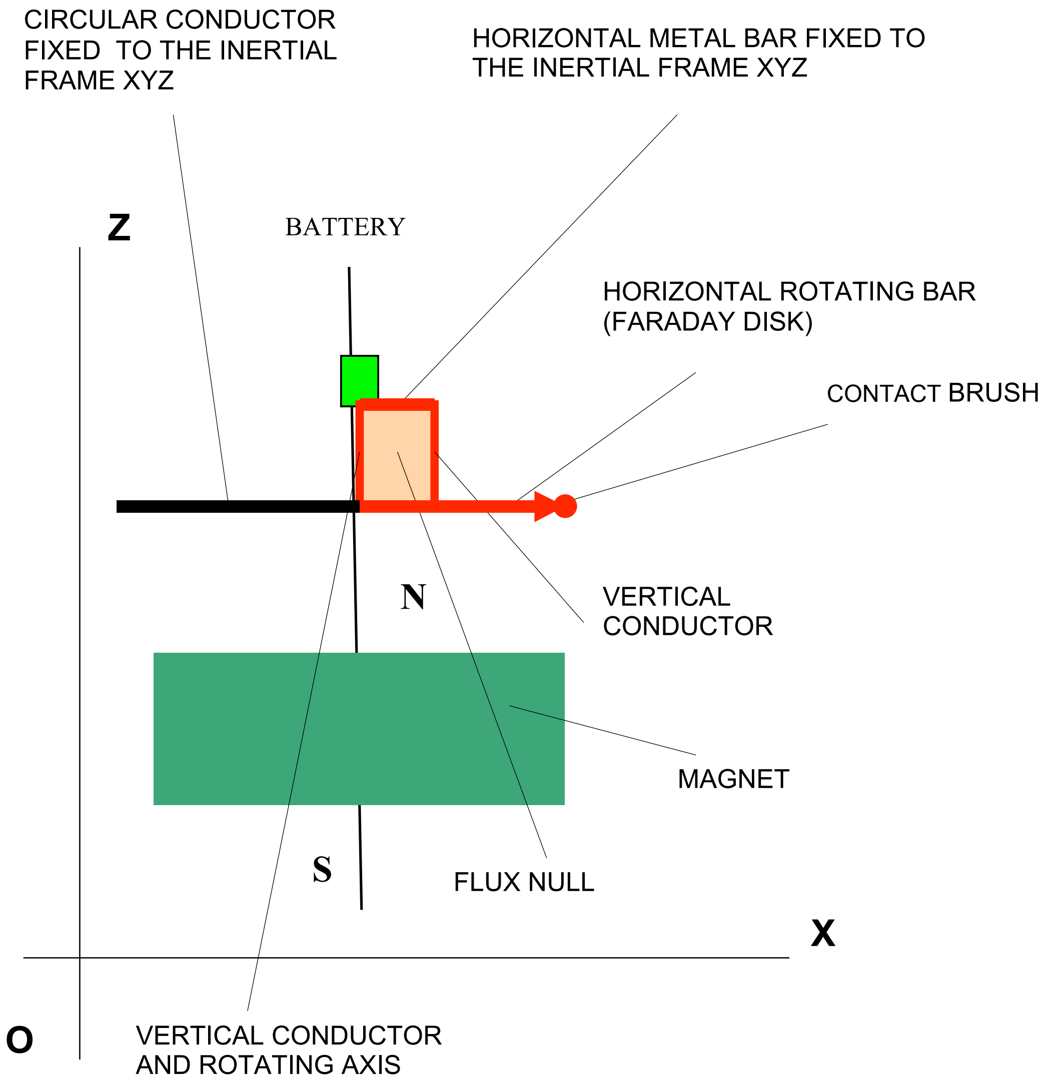


FIG. B (vertical projection)

On the *fixed radial conductor* acts the LORENTZ force **F** , normal to the same; another identical force, acts on the *bar–disc of FARADAY*, producing two pair of forces, equal and opposed; only turns this last *bar,* because the *radial conductor* is fixed with respect to inertial frame **XYZ**. (see Fig. **A** and **B**). At first sight it seems that the angular momentum is conserved, as it demands the Classical Dynamics (CD), but if the *radial conductor* is *blinded* with respect to the magnetic field, stops existing the normal LORENTZ force, but the FARADAY disk will continue turning. Thus it is allowed to affirm that in this motor the *angular momentum is not conserved.*[7]. If both radial bars could turn freely, then we would have two FARADAY's disks, superposed, that turn in inverse sense[8]. There is no *action-reaction* between both.

Also, observing the Figures **A** and **B**, one concludes that the circuit, to apply the *Induction Law of FARADAY or rule of the flow*, consists of a *horizontal sector* (fig. **A**) and a *vertical rectangle* (fig. **B**), and in the last one the flow is null by the symmetry of the system, forming both a *dihedron;* in addition, the *rectangle* surface can be reduced to zero when both radial conductors were practically coplanar. Obvious the result would be the same one obtained applying the "LORENTZ's force"[9]. Consequently the FARADAY disk *does not constitute an exception to the "flow rule".*

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[7] Professor ALBERTO SERRA-VALLS in his book, *El Motor Turbo Electrodinámico y la Nueva Ley de Inducción,* after *blinding* the external conductor, reaches the same conclusion, but does not accept it because it seems to him "impossible". Textually writes: "Cuando el año 61me percaté que el conductor que conecta el borde del disco de FRADAY constituye el estator me pregunté si era posible blindar dicho comductor del campo magnético del imán. En caso afirmativo, no podría funcionar sin violar la Ley de la Conservación del Momento Angular. Por más intentos que hice de blindar el conductor, el disco no dejó de funcionar. No pudiendo medir la fuerza de la reacción sobre el conductor y no creyendo en la violación de la ley; (...)"

[8] *Vid. ibidem.* pp, 47–49 y pp. 55–56 .

[9] *Ibidem*. pp. 44–47 .

NEWTONIAN TRAJECTORY

The study concentrates in an elliptical trajectory around the Sun (according to the CD). The tangential acceleration is $dv/dt > 0$ when the movement is in the direction of the *perihelion,* and is $dv/dt < 0$ when the star moves away towards the *aphelion* (to see SCHEME of Fig. 1).

SCHEEME

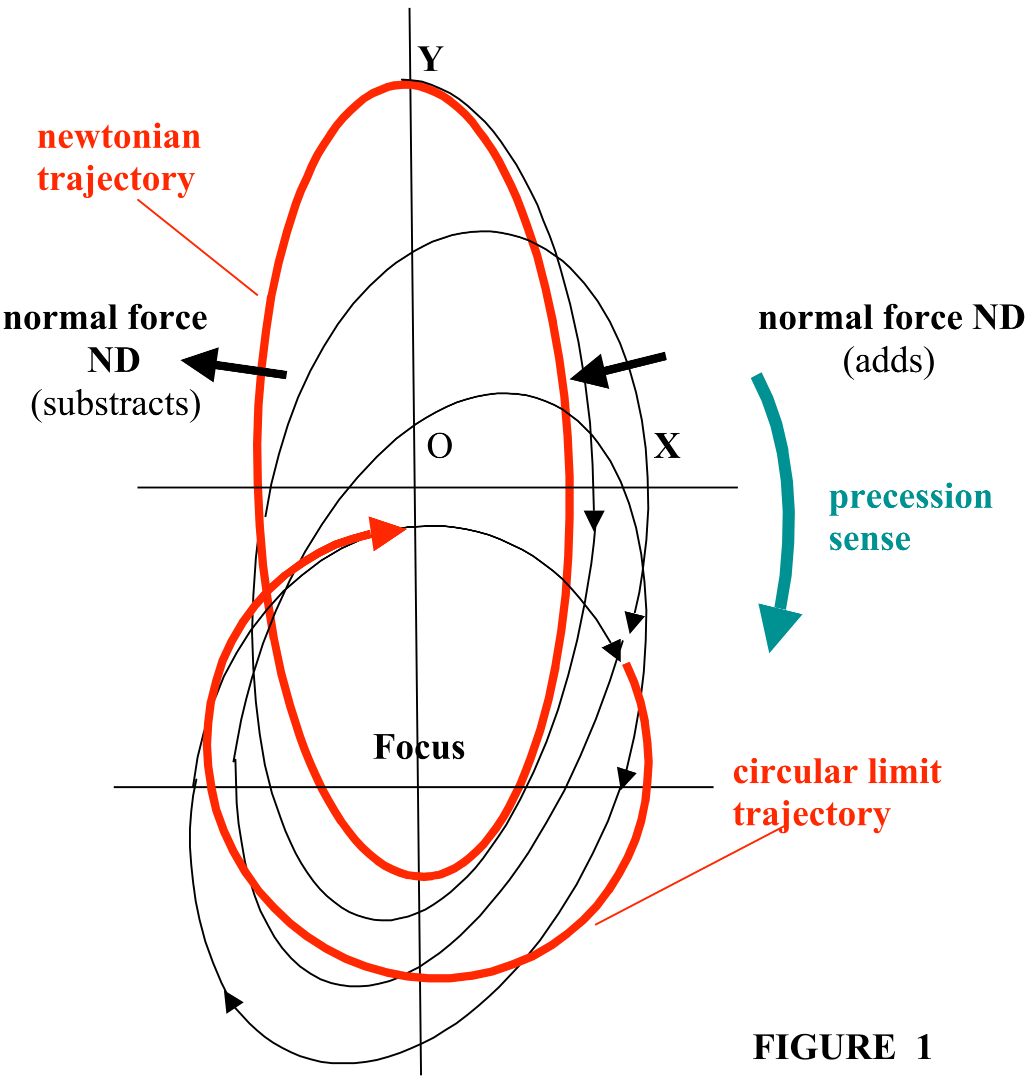


FIGURE 1

Nevertheless, in the light of the ND[10], the total force that acts on the planet of mass m is:

$$\boldsymbol{F} = m\dot{v}\boldsymbol{s} + \tfrac{1}{2}\dot{m}\boldsymbol{v} - m\frac{v^2}{\rho}\boldsymbol{n} - mv\frac{\dot{v}}{\dot{\rho}}\boldsymbol{n} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\boldsymbol{n}$$

In the present case, being small the acceleration *dv/dt,* can be considered constant mass m *,* and the preceding expression is reduced to,

$$\boldsymbol{F} = m\dot{v}\boldsymbol{s} - m\frac{v^2}{\rho}\boldsymbol{n} - mv\frac{\dot{v}}{\dot{\rho}}\boldsymbol{n} \qquad (1)$$

The last term corresponds to the *supplementary normal force* of the ND, indicated in Fig 1, causing the precession of the trajectory that, in addition, become deformed in each cycle until finishing, asymptotically, in stable circumference. This force is *added* or s*ubstracted* to the corresponding one of the CD, according to *dv/dt positive* or *negative,* as it is indicated in (1) and Fig 1.

NOTE:

In order to facilitate the understanding we included the study of the *Supplementary Normal Acceleration* SNA, departure point of the ND, that is included at the end of these experimental tests.

[10] *Vid.* JOHN RIUS–CAMPS, *The Dynamics of Irreversible Mechanical Systems.* Ed. ORDIS. Barcelona. (revised 2009).

PRECESSION OF THE GYROSCOPE

The gyroscope, whose axis pivots in a fixed point O on a horizontal plane OXY, referred to an *inertial frame* with respect to which that point is in rest (and under the action of gravity **g**), precesses around axis OZ (see Fig 1).

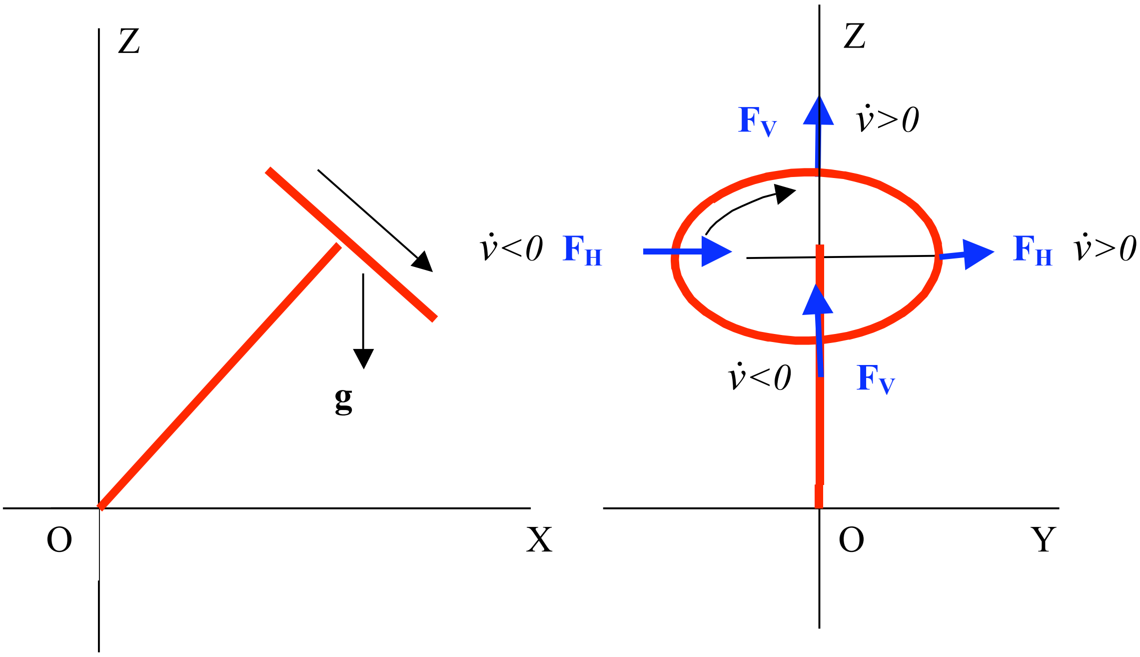
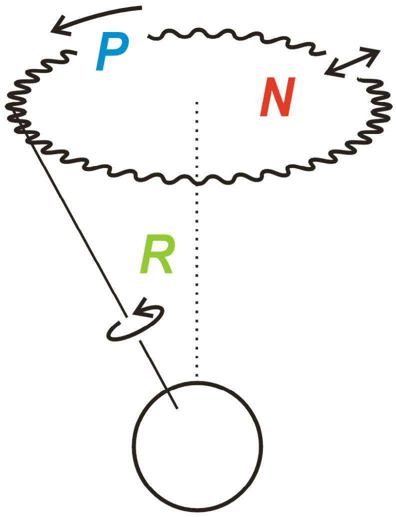


FIG. 1

Being subject to gravity **g**, the gyroscope will precess horizontally in the same direction of rotation. If fixed in the starting point of the figure and is loosen, begins his fall and so the mass of the *right* of the ring undergoes a tangential acceleration $\dot{v}>0$ whereas in the one of the *left* is $\dot{v}<0$ This fact originates the indicated horizontal forces $\mathbf{F_H}$, due to the *Supplementary Normal Acceleration* of the ND, that initiate the precession; but this movement is cause, as well, of the accelerations $\dot{v}>0$ and $\dot{v}<0$ on the *upper* and *lower* mass of the *ring,* respectively, originating the *vertical forces* $\mathbf{F_V}$; due also to the presence of the *Supplementary Normal Acceleration*, that raise the gyroscope preventing his fall. At the beginning of the precession, departing from the starting point at rest, some time is needed to acquire stable rotation; and a superimposed *nutation* appears which is declining until to disappear when the movement is stabilized (see Figure. 2).



GYROSCOPE

P = *precession movement*
N = *nutation movement*
R = *gyroscope rotation*

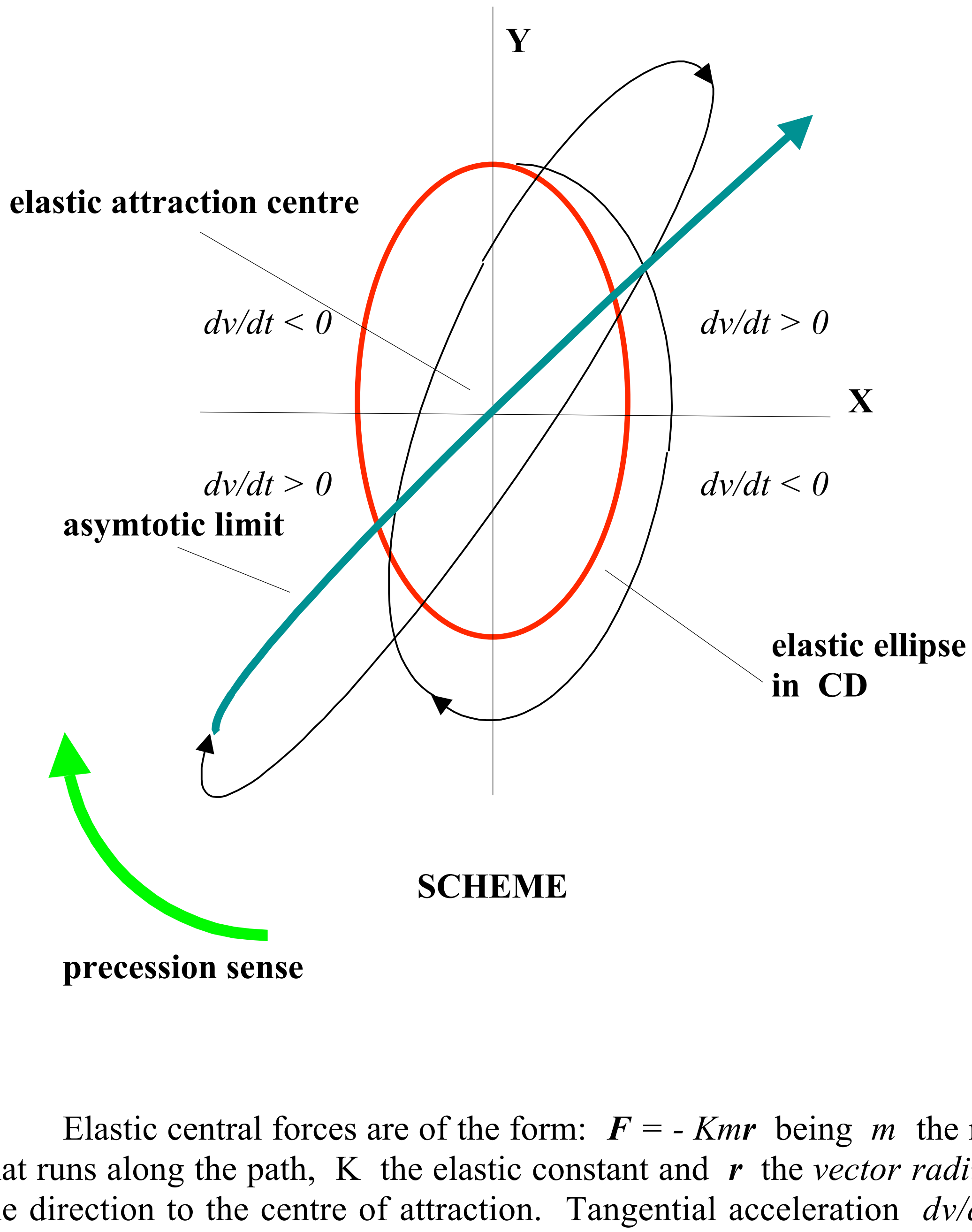
FIG. 2

NOTES

1. It is assumed that the mass of the *gyroscope* focuses on its ring.

2. To facilitate the understanding, we include the study about the *Supplementary Normal Acceleration* (SNA), starting point of the ND..

ELASTIC TRAJECTORY



SCHEME

Elastic central forces are of the form: $\boldsymbol{F} = - Km\boldsymbol{r}$ being m the mass that runs along the path, K the elastic constant and $\boldsymbol{r}$ the *vector radius* in the direction to the centre of attraction. Tangential acceleration dv/dt is *positive* when mass m runs towards the attraction centre, and *negative* when the movement is in opposite sense (see SCHEME).

In the ND the expression of *central force* in polar coordinates, is given by

$$\boldsymbol{F} = m(r\dot{\theta}^2 + r^2\dot{\theta}\frac{\ddot{\theta}}{\dot{r}} + \ddot{r})\hat{r} + \tfrac{1}{2}\frac{\dot{m}}{\dot{r}}(r^2\dot{\theta}^2 + \dot{r}^2)\hat{r}$$

And in the intrinsic inertial trihedron its expression is

$$\boldsymbol{F} = m\boldsymbol{a} - mv\frac{\dot{v}}{\dot{r}}\hat{n} + \tfrac{1}{2}\dot{m}v\hat{s} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{r}}\hat{n}$$

In our case we can consider *constant* mass m, and the last expression reduces to

$$\boldsymbol{F} = m\boldsymbol{a} - mv\frac{\dot{v}}{\dot{r}}\hat{n}$$

where the last term is the *normal force* of the ND superimposed on the $m\boldsymbol{a}$. of CD. The path in this ND is no longer an ellipse, but precesses asymptotically towards an *straight oscillation* (see SCHEME).

NOTA:

To facilitate the understanding, we include the study about the *Supplementary Normal Acceleration* (SNA), starting point of the ND..

THE HAMMER EFFICACY

The hammer is an instrument as old as humanity. Why it is as effective in its diverse uses? According to classical Dynamics (CD) it is quite simple: when handled it acquires a kinetic energy $(1/2)mv^2$ which in the stroke should be transformed into another type of energy, thermal and elastic fundamentally, in order of maintaining the conservation principle. To better illustrate, we can consider the current case of nailing a large nail, through both components of a rustic wooden door, to join the tables with the same structure, clenching it for best fixation. Interestingly in detail this last operation because the nail protrudes a few centimetres and must be folded with the hammer blows being perfectly embedded in the wood; but is not sufficient to achieve this, as the nail head is protruding some *mm* due to retreat by the blows. The action of another operator with another hammer, caught by hand by the steel becomes necessary, and supporting it flat over the head of the nail, while on the other side is riveted by the first hammer; the result is that the bent part and also the head are fully embedded in the wood. To achieve this result with a press, it should exercise a surprisingly significant pressure. Krupp to forge steel, designed the famous stamper hammer, the "Bertha Krupp", that beat iron at very high temperature. A giant press had failed doing it. The effectiveness of this simple tool is clearly manifested.

At the light of the ND the explanation is as follows: in the absence of elastic rebound, the kinetic energy $(1/2)mv^2$ must change in heat, but its transmission is slower than the stroke instant, and for energy conservation the only possibility is that inertial mass m "increase"; in the ND the mass is not a *constant*, may vary with time t. The *total force* is given by the expression:

$$\boxed{\boldsymbol{F} = m\dot{v}\boldsymbol{s} + \tfrac{1}{2}\dot{m}\boldsymbol{v} - m\frac{v^2}{\rho}\boldsymbol{n} - mv\frac{\dot{v}}{\dot{\rho}}\boldsymbol{n} - \tfrac{1}{2}\dot{m}\frac{v^2}{\dot{\rho}}\boldsymbol{n}} \qquad (1)$$

In our case the path followed by the hammer is considered straight and (1) is reduced to:

$$\boxed{\boldsymbol{F} = m\dot{\boldsymbol{v}}\boldsymbol{s} + \tfrac{1}{2}\dot{m}\boldsymbol{v}}$$

where the second term corresponds to the variation with time t of the inertial mass m in ND.

This "hammer effect" acts also in the flight of many insects as the "Bumblebee" *("Bombus terrestris")*, cited in the present proofs.

NOTE:

To facilitate the understanding, we include the study about the *Supplementary Normal Acceleration* (SNA), starting point of the ND..

SUPPLEMENTARY NORMAL ACCELERATION
a_n*

KINEMATIC A ND DYNAMIC MEANING OF ANGULAR VELOCITY ω*

1. At first, we begin with the study of the trajectory of a material point *m* from the kinematical point of view exclusively. In classical kinematics a differential ***ds*** of arc in the trajectory is substituted by the corresponding in the osculating circle in order to calculate the acceleration vector. For this purpose a FRENET's referential frame is used. The acceleration components in this circle are

$$\boldsymbol{a}_s = (dv/dt)\boldsymbol{s} \qquad \text{and} \qquad \boldsymbol{a}_\rho = -(v^2/\rho)\boldsymbol{n} \qquad (1)$$

Where ***s*** and ***n*** are the *versors*. In this frame whose *versors* are ***s*** , ***n*** , ***b*** the *positive sense* is determined by the velocity sense, by the sense towards convexity and by the vector product: $\boldsymbol{b} = \boldsymbol{s} \times \boldsymbol{n}$, respectively. The angular velocity is

$$\boldsymbol{\omega} = (v/\rho)\boldsymbol{b}$$

A definite trajectory has a well defined *evolute,* and in the calculation of the normal component in the expressions (1) the differentials *dv* and *dρ* are obviously not taken into account. But, as we will demonstrate, when $dv \neq 0$ and $d\rho \neq 0$, the *arc* of the *evolute* does not correspond with the real one: it turns locally at an angular velocity

$$\boldsymbol{\omega}^* = (dv/d\rho))\boldsymbol{b}$$

and the same thing occurs with the corresponding *arc* of *trajectory* in the osculating circle.

In order to explain the kinematics meaning of this angular velocity $\boldsymbol{\omega *}$, we shall study an element $\boldsymbol{ds}$ of trajectory which corresponds to the $\boldsymbol{d\rho}$ of the *evolute;* they are both located on the plane of osculation (see Fig.1 when $dv/dt > 0$; and Fig. 2 when $dv/dt < 0$). Thus we can consider the trajectory as being locally plane and referred to an intrinsic frame with *versors* $\boldsymbol{s}$, $\boldsymbol{n}$, $\boldsymbol{b}$, formed by the *tangent, normal* and the *binormal.* The *arc* $\boldsymbol{ds}$ of the trajectory is determined by the points A , B , and the $\boldsymbol{d\rho}$, of the *evolute,* on account of its equivalent points A , B

. The speed of the particle in A is v and in B it is $v + dv$. The radii of curvature at these points are: $\rho + d\rho$ and ρ . The angle turned by the radius of curvature when it passes from A to B is

$$d\theta = ds/\rho$$

and the corresponding angular speed will be as we have seen

$$\omega = d\theta/dt \qquad (\text{with} \quad \boldsymbol{\omega} = \omega\, \boldsymbol{b})$$

We can also write: $\omega = v/\rho$, which evidently does not depend on dv and $d\rho$. When we calculate the centripetal acceleration we get the last expression (1):

$$\boldsymbol{a}_\rho = -(v^2/\rho)\boldsymbol{n}$$

in which the increases dv , $d\rho$, are not considered, as they do not affect it. It is the consequence of replacing the $\boldsymbol{ds}$ of *trajectory* by the corresponding one in the *osculating circle* at the same point. However, if we observe the real trajectory carefully, we see that is characterized by having a well determined *evolute* (see Fig. 1, when $dv/dt > 0$, and Fig. 2, when $dv/dt < 0$). When dv is dispensed with, in the study of centripetal acceleration, it means that starting out from point A we arrive at B' but not at the real point B ; and the same should occur to the centre of curvature: A is located in the *evolute,* as it is the starting point, but B' lays outside of the *real evolute* (see Fig. 1 and Fig. 2), whose point is B . It is evident that the centripetal acceleration is correctly determined, but it is also clear that the *arc* of the *evolute* must coincide with what is determined by points A and B in the figure, and not by the A and B' , as happens when dv and $d\rho$ are omitted. In order to rectify this deficiency it is necessary to rotate AB' an angle

$$d\theta^* = BB'/d\rho$$

so that it coincides with the $\boldsymbol{d\rho}$ in the *evolute,* with a *finite* angular velocity (see Fig. 1 and Fig. 2) whose module is expressed by

$$(BB'/d\rho)/dt = (d^2s/d\rho)/dt = dv/d\rho = d\theta^*/dt = \omega^*$$

This angular velocity shows that the simplification of replacing the trajectory with the osculating circle in each point means that it is necessary to turn locally the *arc* of the *evolute*, with angular velocity $\boldsymbol{\omega^*}$, so that it coincides with the real one. But this *arc* AB' of the *evolute* must be *normal* to the corresponding AB'' of the *trajectory,* rotated also $d\theta^*$, with respect to the initial AB (see Fig. 1 and Fig. 2). It will be necessary to turn AB' this angle, in the *same sense* (when $dv/dt > 0$) and in the *opposite sense* (when $dv/dt < 0$), so that it coincides with the *real* one . As a result, the *radius* ρ has increased in a second order infinitesimal amount:

$$B'B'' = dsd\theta^* \qquad \text{(when } dv/dt > 0\text{)}$$

and

$$B'B'' = -dsd\theta^* \qquad \text{(when } dv/dt < 0\text{)}$$

and the immediate result is a *supplementary normal acceleration:*

$$\alpha_\rho^* = B'B''/dt^2 = ds\, d\theta^*/dt^2 = v\omega^* \quad (\text{when } dv/dt > 0)$$

$$\alpha_\rho^* = B'B''/dt^2 = -\, ds\, d\theta^*/dt^2 = -\, v\omega^* \quad (\text{when } dv/dt < 0)$$

superimposed to the *normal acceleration* a_ρ (1). So the *total normal acceleration* is

$$\begin{aligned} a_\rho + a_\rho^* &= -(v\omega + v\omega^*) = -v(\omega - \omega^*) \\ a_\rho + a_\rho^* &= -(v\omega - v\omega^*) = -v(\omega + \omega^*) \end{aligned} \tag{2}$$

in the two possible cases.

Obviously the *tangential acceleration* $a_s = dv/dt$ remains unchanged. Taking in account (2)we get in vector form the *total acceleration:*

$$\begin{aligned} a_s\boldsymbol{s} + a_\rho\boldsymbol{n} + a_\rho^*\boldsymbol{n} &= \boldsymbol{a} + v\omega^*\boldsymbol{n} = \boldsymbol{a} - \boldsymbol{v}\times\boldsymbol{\omega}^* \\ a_s\boldsymbol{s} + a_\rho\boldsymbol{n} + a_\rho^*\boldsymbol{n} &= \boldsymbol{a} - v\omega^*\boldsymbol{n} = \boldsymbol{a} + \boldsymbol{v}\times\boldsymbol{\omega}^* \end{aligned} \tag{3}$$

respectively.

2. From the dynamical point of view, if we want to calculate the *total normal force* correctly, the *total normal acceleration* (2) must be taken into account. So the expression of this *normal force* will be

$$\boldsymbol{f_n} = -mv\,(\omega - \omega^*)\boldsymbol{n} = m\boldsymbol{v} \times (\boldsymbol{\omega} - \boldsymbol{\omega}^*)$$

and

$$\boldsymbol{f_n} = -mv\,(\omega + \omega^*)\boldsymbol{n} = m\boldsymbol{v} \times (\boldsymbol{\omega} + \boldsymbol{\omega}^*)$$

in both possible cases.

Now, in summary, taken in account the expression (3), the *total force* acting on the material point is

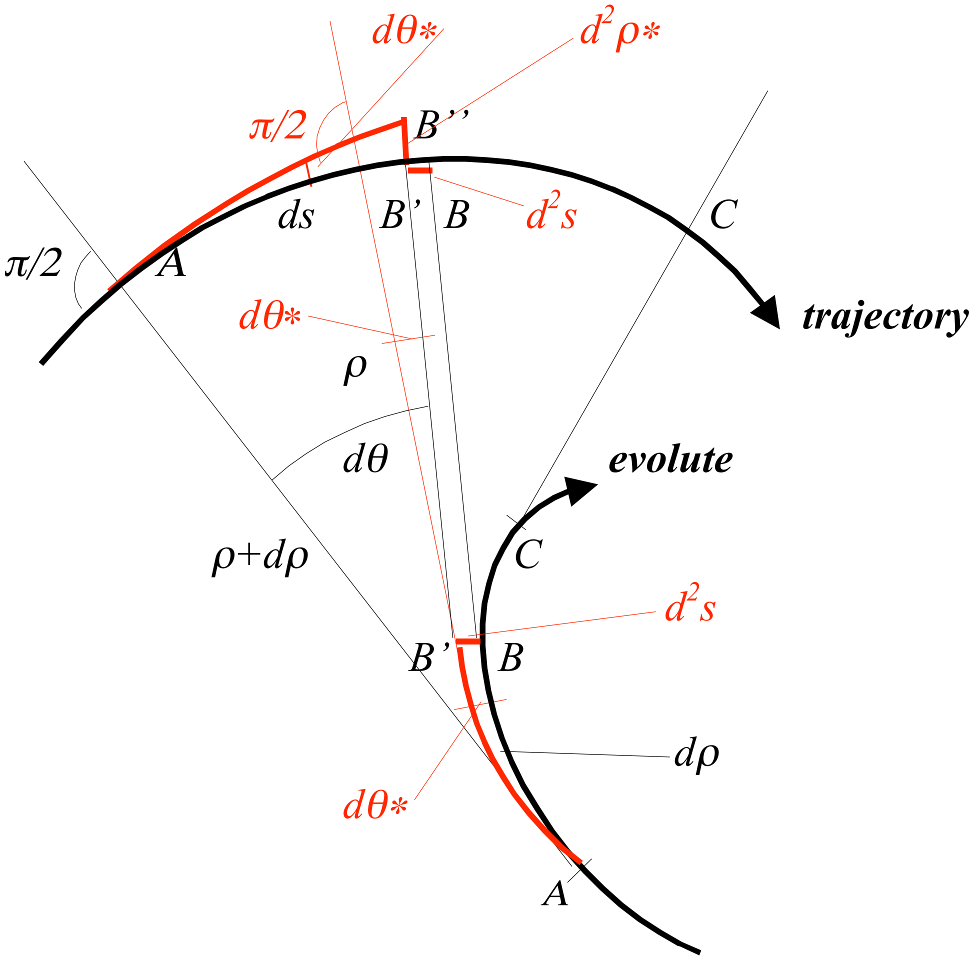
$$\boxed{\boldsymbol{f} = m(\boldsymbol{a} \pm \boldsymbol{v} \times \boldsymbol{\omega^*})} \qquad (4)$$

(which is *isomorphic* with the LORENTZ electromagnetic force).

The angular velocity $\boldsymbol{\omega^*}$ will only cease to exist when the trajectory is a circumference or the speed v is constant, as it follows observing Fig.1 and Fig. 2 (see also the cases of Fig. 1' and Fig. 2').

The result (4) is surprising: even more so when we remember that "LORENTZ's force" is exclusively experimental. Moreover, in FRENET's trihedron the value v of speed is always *positive* in the sense in which the particle is moving . We know that while the moving point follows the trajectory, the *centre of curvature,* at the corresponding point, describes the *evolute*, and we can take the sign of $d\rho$ as *positive* because the sense of its movement follows the *changing sense* of the velocity $\boldsymbol{v}$. This result is of the major importance (see the two possible cases in Figs. 1, 2, and 1', 2') because $\omega = dv/d\rho$ *changes sign,* when the movement is inverted (*dv changes to $-dv$* whereas $d\rho$ *,* in the *evolute does not change).* When the *movement is inverted,* the *versor* $\mathbf{s}\times \boldsymbol{b} = -\boldsymbol{n}$ *maintains its sense,* because $\boldsymbol{s}$ and $\boldsymbol{b}$ simultaneously change sign; but the *supplementary normal acceleration* $\boldsymbol{a^*} = \boldsymbol{v}\times \boldsymbol{\omega^*} = \mathbf{s}\times \boldsymbol{b} v\omega^*$ *changes sing* when ω^* *changes to* $-\omega^*$. Consequently, the ***reversibility*** of the trajectory in CD ***does not hold up*** in the ND,

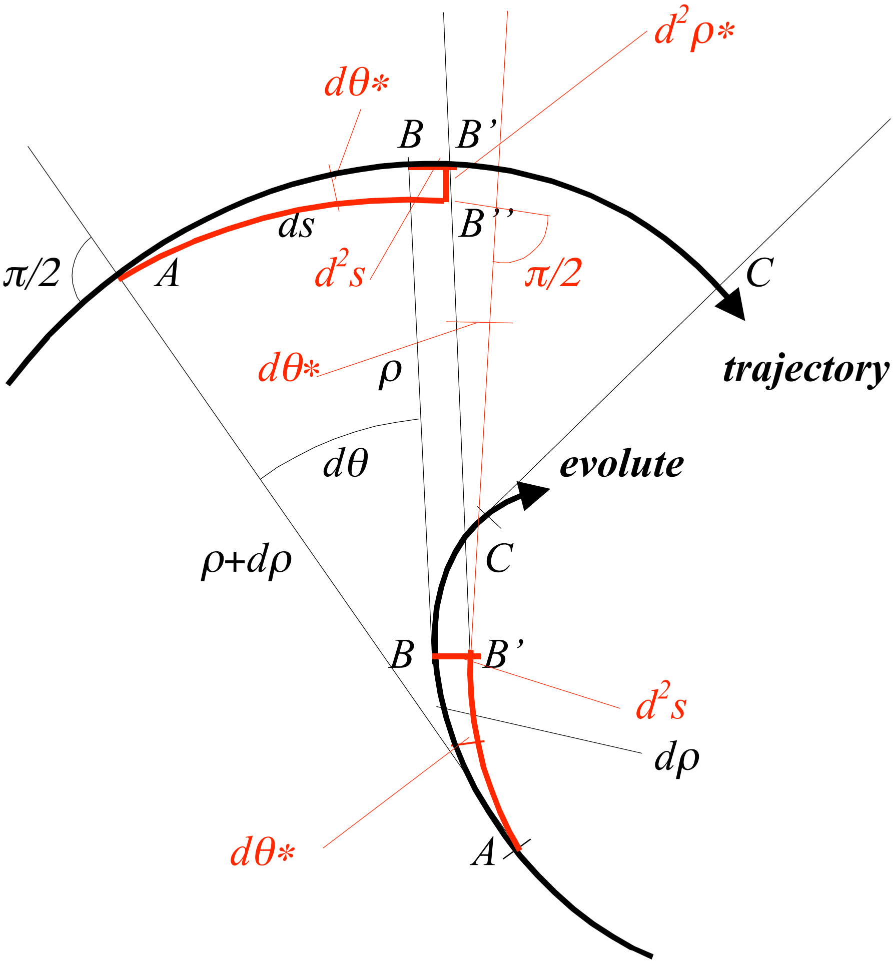
The ***CHAOS*** presence in physical phenomena has its foundation in this ***irreversibility.***



Supplementary Normal Acceleration *(*when *dv/dt < 0)*

$$a_n* \ = \ d^2\rho*/dt^2$$

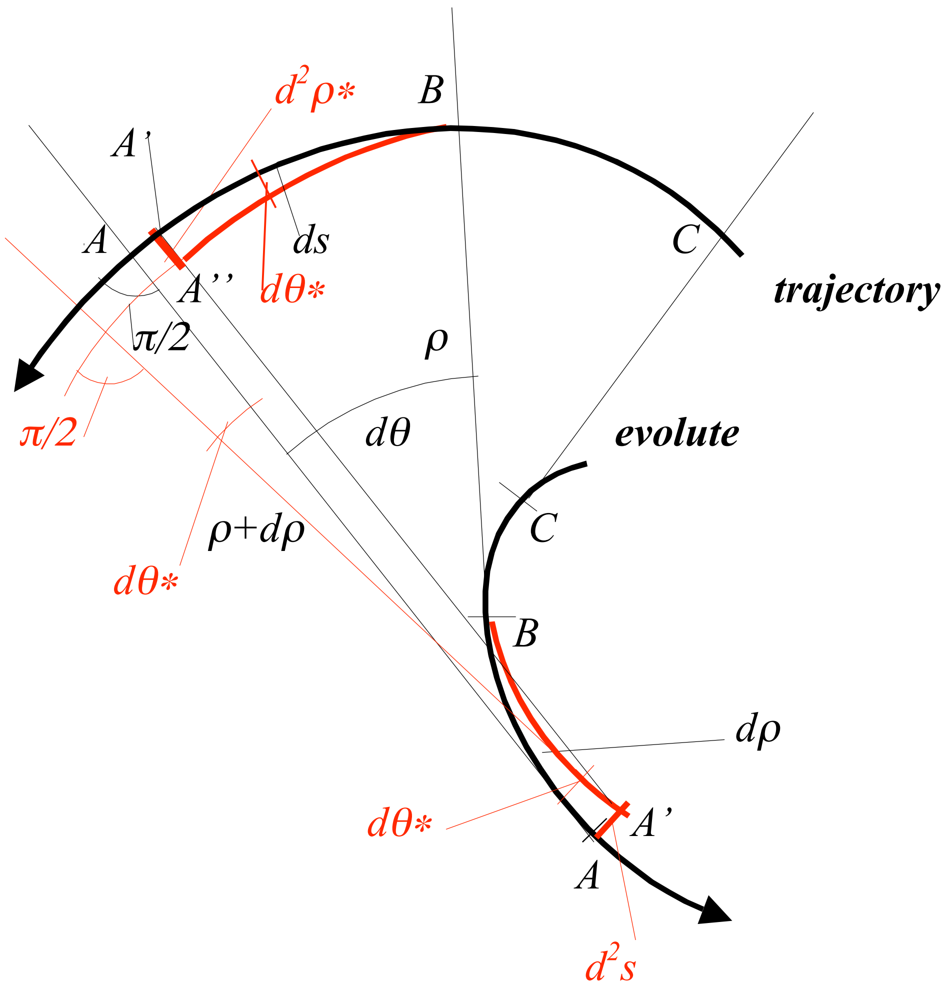
FIG. 1



Supplementary Normal Acceleration (when *dv/dt > 0*)

$$a_n* = d^2\rho*/dt^2$$

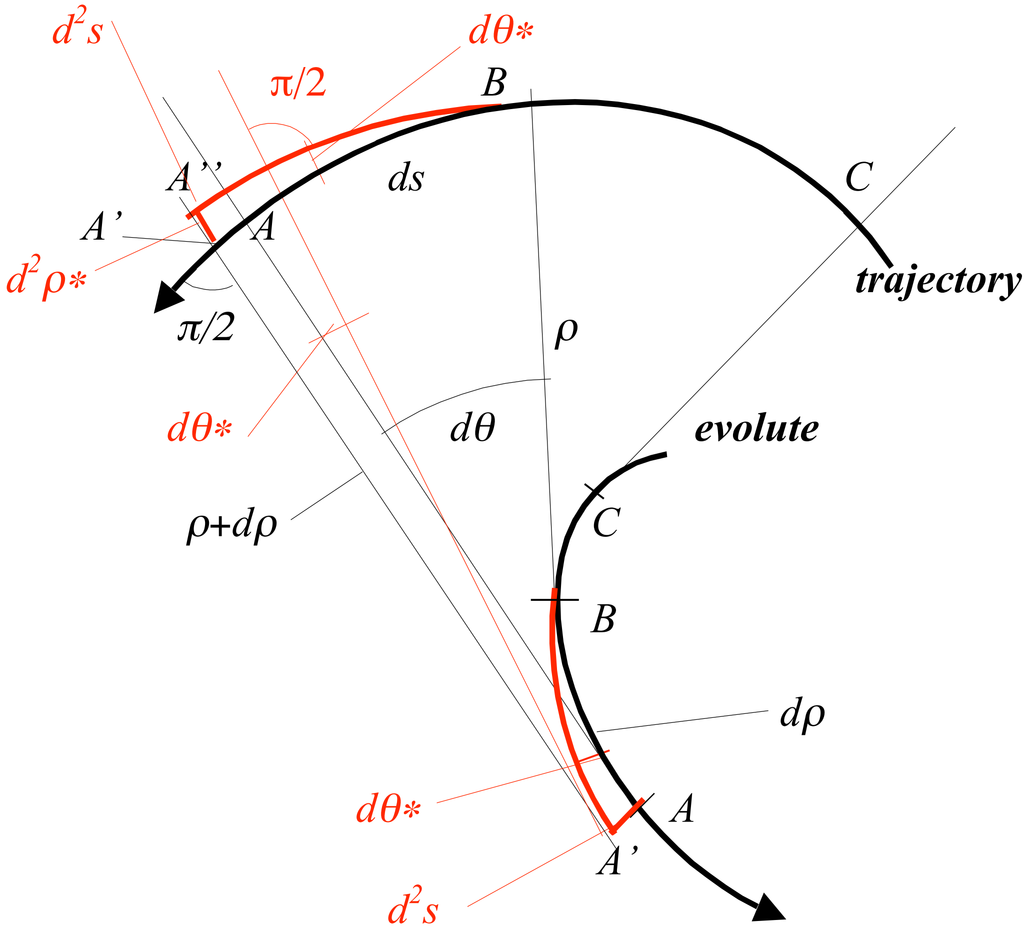
FIG. 2



Supplementary Normal Acceleration
(running in *inverse direction*, with $dv/dt < 0$)

$$a_n* = d^2\rho*/dt^2$$

FIG. 1'



Supplementary Normal Acceleration
(running in *inverse direction*, with $dv/dt > 0$)

$$a_n* = d^2\rho*/dt^2$$

FIG. 2'

STUDY OF THE FORCE EXPRESSION IN THE NEW DYNAMICS (ND).

1. By way of introduction it must be said that in this ND we can no longer set out from the Newtonian "Fundamental Equation", which gave us the expression of force, as it would only be valid in singular cases, as a result of what we said before. However, in order to construct the ND we must set a starting point that enables us to elaborate the new theory; the CD is a particular case of this. This starting point, in the framework of the *Three Fundamental Laws*, is the assertion that kinetic energy in a system of particles can be expressed thus:

$$\boxed{U_c = (1/2)mv^2}$$

when m is the total mass of the system and v is its *average quadratic speed*. This energy is the sum of the kinetic energy in each one of the system's particles, which satisfy analogous expressions. We are not considering relativistic problems with high speeds here. As we shall see later on, the mass of the system in this ND is not necessarily a constant, but instead it generally depends on time. Normally, and while it is not particularly specified, we will assume that the system has an inertial Cartesian frame of coordinates for reference.

In Classical Dynamics the potential energy of a system is said to be conservative if it depends only on the position of the particles, that is, it is independent of time. This energy cannot generally be written as the sum of potential energy in each particle –as is the case with total kinetic energy–: its expression is *global*, as it depends on the position of all the masses in the system, and it is not possible to assign to each one of them a potential energy which depends exclusively on its position. It is nonetheless possible to give each particle a potential energy which depends on both position and time; this can be done by simply making the coordinates and the velocities of the other bodies in the expression of the total energy dependent on time. In an energetically closed system, for each particle m –if we call $U_{pi}(P_i ,t)$ its potential energy and $U_{ci}(P_i) = (1/2)m_iv_i^2$ its kinetic energy– we can write by virtue of the *First Fundamental Law*

$$\boxed{U_{ci}(P_i) \;+\; U_{pi}(P_i,t) \;=\; C_i} \qquad (i = 1,2,3,...,n) \qquad (1)$$

in which

$$U_{pi}(P_i,\, t) \;=\; \Sigma_j U_{cj}[P_j(t)] \;+\; U_p{}^{(i)}[P_i,\, P_1(t),\, P_2(t),\, P_{i-1}(t),\, P_{i+1}(t),...P_n(t)]$$

And the result when these are all put together extends to all the variables *except (i)*. For the system of n particles m_i the result when they are added together the expressions (1), will be

$$\sum_{i=1}^{n} U_{ci}(P_i) + U_{pi}(P_i,t) = U_c + \sum_{i=1}^{n} U_{pi}(P_i,t) = C$$

that is

$$U_c \;+\; U_p \;=\; C$$

which expresses the conservation of energy in the system, as was to be expected. It should be noted that in the expression: $U_{ci}(P_i) = (1/2)m_i v_i^2$ it is always $v_i = v(P_i)$, since velocity, by its very nature, implies a change of place and for this reason *depends on the position* of the particle, except for trivial cases where this functional relationship cannot be established. It is also always possible to make the position depend on time, but it must be stressed that here time is a simple parameter, by which the positional variables can be expressed, and *not an independent variable* as it is with non-conservative potential energy: $U_{pi}(P_i,\ t)$. In the light of these reflections we can write the (1) as follow:

$$U_{ci}(P_i) + U_{pi}(P_i,\, t) \;=\; C \;\Rightarrow\; \quad (1/2)m_i v_i^2 + U_{pi}(P_i,\, t) \;=\; C \qquad (2)$$

which gives the paradox that $U_{pi}(P_i,\ t)$ can be written as a function of the position P_i and independent of time. The only solution, generally, is that mass m_i cannot be considered constant in this ND but must rather be

$$\boxed{m_i = m_i(t)}$$

and it is obviously that $(1/2m_i(t)\, v_i^2 = U_{ci}(P_i, t)$. This conclusion is clearly of major importance.

2. We are already in a position to find an expression for the force that acts on a particle of mass m which follows a trajectory in relation to a frame of inertia; for the sake of simplicity and clarity we shall start with an idealized case in which the mass is constant and, as a result, the potential is conservative. Since it is a closed system, according to the *First Fundamental Law* it is true that

$$(1/2)m_o v^2 + U_p(P) = C$$

in which $v = v(P)$ and $m = m_o = constant$. The particle follows a determined trajectory and, since this is known, its kinetic energy depends on a unique variable which determines its position on the same; for instance: the arc travelled from the starting point, the radius of curvature at each point, etc., that is, we are dealing with *intrinsic variables*. Thus, our study of the *force* which acts on the particle when it travels along this trajectory, is *local*. Let us imagine a differential arc situated on the plane of osculation at point P ; in this way, still speaking in general terms, we can consider the trajectory as being locally plane and as a reference we shall use FRENET's trihedron, whose unitary vectors or *versors* are: $\boldsymbol{s}$, $\boldsymbol{n}$, $\boldsymbol{b}$, according to the *tangent*, *normal* and *binormal,* respectively. We choose as positive senses: that of the velocity of the particle for $\boldsymbol{s}$, that which goes towards the convexity of the trajectory for $\boldsymbol{n}$, and for $\boldsymbol{b}$ the dextrorsum so that

$$\boldsymbol{b} = \boldsymbol{s} \times \boldsymbol{n} \tag{3}$$

In these conditions we define force according to a variable x on which *all the kinetic energy* U_c of the particle depends

$$\boxed{\boldsymbol{F}_x = (dU_c / dx)\boldsymbol{x}} \qquad (4)$$

with $\boldsymbol{x}$ as the corresponding *versor*.

If we apply this definition to the intrinsic variables: trajectory arc s and curvature radius ρ , in the particular case of $m = m_0 =$ *constant* , we shall have respectively

$$\boldsymbol{f_s} = (dU_c/ds)\boldsymbol{s} = (m_o v dv/ds)\boldsymbol{s} = (m_o dv/dt)\boldsymbol{s}$$
$$\boldsymbol{f_\rho} = (dU_c/d\rho)\boldsymbol{n} = (m_o v dv/d\rho)\boldsymbol{n} \qquad (5)$$

since the variation in the radius of curvature is in accordance with $\boldsymbol{n}$. These two forces depend on how the kinetic energy varies, and in this sense no more variables exist, as we can only consider two intrinsic variables in a plane trajectory. However, we must also take into account the *centripetal force* of the CD, which is *not included* in $\boldsymbol{f_\rho}$ as it does not depend on the variation of kinetic energy but on its value

$$m_o\boldsymbol{a_n} = -m_o(v^2/\rho)\boldsymbol{n} = -(2U_c/\rho)\boldsymbol{n}$$

Consequently, the *total force* acting on m will be the resultant:

$$\boldsymbol{f_o} = m_o\boldsymbol{a} + \boldsymbol{f_\rho} = m_o\boldsymbol{a} + (m_o v dv/d\rho)\boldsymbol{n} \qquad (6)$$

In which the sign, in accordance with $\boldsymbol{n}$, will be *(–)* if we have chosen as positive the sense towards the convexity (as in this case) and it will be *(+)* if this sense is towards the concavity. Another expression for the force $\boldsymbol{f_\rho}$ (5) can be given by writing

$$\boldsymbol{f_\rho} = (m_o v dv/d\rho)\boldsymbol{n} = (m_o dv/d\rho)\boldsymbol{b} \times v\boldsymbol{s} =$$
$$-\boldsymbol{v} \times (m_o dv/d\rho)\boldsymbol{b}$$

since, because of (3), it is $\boldsymbol{n} = \boldsymbol{b} \times \boldsymbol{s}$. As $dv/d\rho$ has the dimensions of an angular speed, we can define it as

$$\boldsymbol{\omega}^* = \omega^* \boldsymbol{b} = (dv/d\rho)\boldsymbol{b} \tag{7}$$

so that

$$\boldsymbol{f_\rho} = -m_o \boldsymbol{v} \times \boldsymbol{\omega}^* \qquad \text{(with } v > 0\text{)}$$

$$\boldsymbol{f_\rho} = -m_o \boldsymbol{v} \times \boldsymbol{\omega}^* \qquad \text{(with } v < 0\text{)}$$

and from (6) we get

$$\boxed{\boldsymbol{f_o} = m_o \boldsymbol{a} \pm m_o \boldsymbol{v} \times \boldsymbol{\omega}^* = m_o(\boldsymbol{a} \pm \boldsymbol{v} \times \boldsymbol{\omega}^*)} \tag{8}$$

which are *isomorphic* with "LORENTZ's force" of electromagnetism:

$$\boxed{\boldsymbol{f_{em}} = q(\boldsymbol{E_{em}} + \boldsymbol{v} \times E_{em})}$$

The result (8) is surprising: even more so when we remember that "LORENTZ's force" is exclusively experimental. Moreover, in FRENET's trihedron the value v of speed is always *positive* in the sense in which the particle is moving . We know that while the moving point follows the trajectory, the *centre of curvature,* at the corresponding point, describes the *evolute*, and we can take the sign of $d\rho$ as *positive* because the sense of its movement follows the *changing sense* of the velocity $\boldsymbol{v}$. This result is of the major importance (see the two possible cases in Figs. 1, 2', pp. 53, 56) because $\omega = dv/d\rho$ *changes sign,* when the movement is inverted (*dv changes to $-dv$* whereas $d\rho$, in the *evolute does not change).* When the *movement is inverted,* the *versor* $\mathbf{s} \times \boldsymbol{b} = -\boldsymbol{n}$ *maintains its sense,* but the *supplementary acceleration* $\boldsymbol{a}^* = \boldsymbol{v} \times \boldsymbol{\omega}^* = \mathbf{s} \times \boldsymbol{b} v \omega$ *changes it* when ω^* *changes to* $-\omega^*$. Consequently, the ***reversibility*** of the trajectory in CD **d*oes not hold up*** in the ND, (see Figs 1 and 2' , pp. 53, 56).

3. We shall now study the case in which $m = m(t)$, in other words, in which (4) is verified:

$$U_c(P, t) + U_p(P, t) = (1/2)mv^2 + U_p(P, t) = C \qquad (9)$$

We have kept the same definition as in (4) for the force depending on $U_c(P, t)$ which acts on m. We shall simply bear in mind that the kinetic energy will depend on position and time, as shown in (9). We shall now determine the forces acting on m following the preceding process. We shall have:

$$\boldsymbol{f_s} = (dU_c/ds)\boldsymbol{s} = (mvdv/ds)\boldsymbol{s} + (1/2)(dm/ds)v^2\boldsymbol{s} =$$
$$(mdv/dt)\boldsymbol{s} + (1/2)(dm/dt)v\boldsymbol{s}$$

$$\boldsymbol{f_\rho} = (dU_c/d\rho)\boldsymbol{n} = (mvdv/d\rho)\boldsymbol{n} + (1/2)(dm/d\rho)v^2\boldsymbol{n}$$

and analogously the *total force* on m will now be

$$\boldsymbol{f} = m\boldsymbol{a} + (1/2)(dm/dt)v\boldsymbol{s} + \boldsymbol{f_\rho} = \qquad (10)$$
$$m\boldsymbol{a} + (1/2)(dm/dt)v\boldsymbol{s} + (mvdv/d\rho)\boldsymbol{n} - (1/2)(dm/d\rho)v^2\boldsymbol{n}$$

and in the light of (8) we can write

$$\boldsymbol{f} = m(\boldsymbol{a} + \boldsymbol{v} \times \boldsymbol{\omega}^*) + (1/2)(dm/dt)v\boldsymbol{s} + (1/2)(dm/d\rho)v^2\boldsymbol{n} =$$
$$\boldsymbol{f_o} + (1/2)(dm/dt)v\boldsymbol{s} + (1/2)(dm/d\rho)v^2\boldsymbol{n} =$$
$$\boldsymbol{f_o} + (1/2)(dm/dt)v\boldsymbol{s} - (1/2)(dm/d\rho)v^2\boldsymbol{s} \times \boldsymbol{b} =$$
$$\boldsymbol{f_o} + (1/2)(dm/dt)v\boldsymbol{s} - \boldsymbol{v} \times (1/2)(dm/d\rho)v\boldsymbol{b}$$

Analogous to the preceding case in which $m = m_o = constant$, we can put:

$$\boldsymbol{E} = (1/m)[\boldsymbol{f_o} + (1/2)(dm/dt)v\boldsymbol{s}]$$
$$\boldsymbol{B} = -(1/m)(1/2)(dm/d\rho)v\boldsymbol{b}$$

with the result

$$\boxed{\boldsymbol{f} = m(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})} \tag{11}$$

Totally parallel to (8). Starting out from this, and with some complementary hypotheses, equations are deduced for this ND which are isomorphic with those of MAXWELL, which govern all electromagnetism, and which will be expounded in the next chapter. In this ND the forces (11) are no longer *invariant* with regard to "GALILEO's transformations", parallel to what happens with electromagnetic forces.

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