Structured Contact Turbulence versus Corona virus Pandemic

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Abstract*: We are going to present a relativistic approach on the origin of turbulence as a structured contact organization of wall-bounded flows gendered by their starting in the case of easily deformable bodies, that is, fluids. But, the rapid changes of dramatic events related to this corona virus pandemic, involving three evolution phases that is onset, growth and extinction, showing a high similarity with the development of wall-bounded flow by flowing fluid when the Reynolds number exceeds a critical value of* log Re = 6, *make us focus on such a rapid event of shock type, herein called a demographic shock. Therefore, the goal of the present paper is to describe the main phases of this unhappy event using a hydrodynamic model along with a Gaian natural self-regulation process.*

Key Words*: Contact hydrodynamic structures, laminar-turbulent transition, structured turbulence, pandemic modeling.*

1. INTRODUCTION

The physical force of a gravitational nature and its relation with the space-time structure is a general relativity problem. The fundamental physical insight behind the theory of general relativity is that the effects of acceleration cannot by distinguished from those of gravity when matter changes are produced. The presence of matter changes, the geometry of space, and acceleration can be experienced in relation to that geometry only in the case of small acceleration according with the Newton's determinism principle. In general, the geometry of space and time are dynamically determined by physical laws that are not given independently. Thus, one knows three dynamical space-time schemes closely connected to the Eigen rotation of the Earth given by Aristotelian, Newtonian and Galilean (less understood) physics, depending on the involved inertial scale: molecular, continuum and cellular scale, respectively. The structured/contact turbulence-like virus spreading at a cellular scale ($< 10^{-6}$m, i.e. alive cell size) is further approached by the mathematical concept of the bundle and gauge connection. According to this concept instead of regarding the spaces of particle interactions

(as gravity-turbulence interactions), these are referred to a kind of "spatial" dimension as being part of a higher-dimensional space-time called a fibre bundle (the internal space of virus pandemic) over base space (which is a space-time of pandemic period itself). Like the contact phenomenon of gravitational structured turbulence [1] the Earth-bound pandemic process must have its own gauge connection.

2. THE HYDRODYNAMIC MODEL FOR A PANDEMIC PROCESS

The diffusion of a "vortex eye" (herein a virus vortex) model proposed for a pandemic spreading, is based on a special two-dimensional solution of the non-stationary Navier-Stokes equations (NSE) along with an own gauge connection. The space-time structure determined by the timeless rotating Earth-planet is a relationship between the gravitation g as a local maximum acceleration, angular velocity ω_E ($T_E = \omega_E/2\pi = 24$ hours with a diurnal regularity) and Euclidean space, when a relative motion V with accelerations of the order g:

$$\beta g = r\frac{\partial \omega_0}{\partial t} \text{ and } \frac{V}{2} = r\omega_0, \qquad (1)$$

is breaking out.

The starting/ "birth" vortex ω_0 along with the velocity V represents the genesis of any relative movement as against the basic Earth rotation, considered as a timeless/absolute reference. This relativistic approach is a holistic one that generalizes the previous dynamical schemes known as Aristotelian, Newtonian and Galilean space-time structures [2], [3], including the structured turbulence with life-like evolution/transition structures.

The evolution (or transition) structures are inertia less space-time waves under the form of genuine gravitational/ gravity torsion waves that are experienced in relation to matter (both inorganic and organic) and gradually changes it. The matter carried by the gravitational waves viewed as inertial/ material waves are called the kinetic trinity: power, kinetic energy and momentum waves derived through a complex osmotic-like process of energy mutation. A special matter is living matter which, on its natural path undergoes energy mutations with the change from its origin "birth" structure seen as an early age, middle age and late age stage. The space-time evolution of any matter is an erosion process itself that is achieved in cascade as onset, growth and end stage/structures, further illustrated in the case of a starting vortex.

The evolution of the starting vortex ω_0 is the backbone of the hydrodynamics, from which more branches have developed as the theory itself: Vortex dynamics [4], boundary-layer theory [5] and vast masses of theoretical, computational or experimental approaches of turbulence in fluids [6-13], but without much progress in understanding turbulence as a physical phenomenon and not the other way around. The key problem of the turbulence-like phenomenon involving fast particle interactions is the mathematical idea of a fibre bundle and its gauge connections along with the initial conditions of a quantum nature, that is, local accelerations of order g. The quantum accelerations have the benefits of using wave-like solutions with a given accuracy for modeling different rapid non-stationary contact phenomena like the structure evolution of turbulence and pandemic spreading.

Herein, the initial/starting condition is given by the external distribution of a potential vortex and an internal distribution of a starting/vortex-like Rankine vortex, that is the twisted/concentrated vortex bundle from which the vortex fibres diffuse and/or disperse along the path of its evolution almost without inertia, i.e., at the molecular and cellular scale. The spreading manner, that is, diffusion or dispersion process of a vortex (the concept of concentrated boundary vorticity, CBV), depends on the critical Reynolds number (a

dimensionless ratio of inertial to viscous force) of flowing fluids closely connected to the critical Earth-frequency, $f_E \simeq 10^{-5}$ Hz, numerically equal to the kinematic viscosity and the inverse of an universal critical Reynolds number, $\mathbf{Re}_{cr}$ [1, 2].

For $\mathbf{Re} \geq \mathbf{Re}_{cr}$, the spreading of fluid mass embraces the form of inertial kinetic waves, that is, kinetic trinity-power, kinetic energy and momentum, along with diverse propagation regimes, depending on inertial mass sizes and impact/ starting velocities. From the stand point of continuum mechanics reflected by NSE, the inertial kinetic waves are propagated as dissipative traveling, soliton-like coherent structures, firstly visualized in water boundary-layer flow by Lee [14], [15], and simulated by Dumitrescu and Cardos in a gaseous boundary-layer flow [16], [17].

For $\mathbf{Re} \geq g\mathbf{Re}_{cr}(\mathbf{10^6})$, the water-like fluids experience the degeneracy of molecular structures along with their change to different ones. In the case of these fluids, for the range of Reynolds number less Re = 10^6 diverse transition regimes are produced, viewed experimentally as transitional hydrodynamics.

In the case of air-like fluids, for Re $\geq 10^6$, that is gaseous flows with M $\geq$ 1/3, and cell size < 1µm, the flows become pre-compressible and gravitational-shear waves are produced at a fluid-solid contact surface.

The inertial contact waves are visualized as standing wall wakes little understood and called "hairpin vortex" coherent structures. Recently, one has noted that these structures are dispersive soliton-like gravitational shear-waves, that are propagated in bulk as packets of a "kinetic trinity", that is, power-kinetic energy-momentum, called structured wall turbulence, until the starting compressed inertia, is gradually destroyed and isotropic state of stress is restored.

In essence, it is the problem of a diffusion equation for a vortex that springs in a viscous fluid at the onset of the relative motion *V*:

$$\frac{\partial \omega}{\partial t} = \frac{\nu}{r} \frac{\partial}{\partial r}\left(r \frac{\partial \omega}{\partial r} \right), \tag{2}$$

which can be rendered as an ordinary non-linear differential equation (ODE):

$$\Omega'' + \frac{1}{\zeta}\left(1 + \frac{(2\zeta)^{2/n}}{2n} \right)\Omega' + \frac{(2\zeta)^{2/n}}{n^2\zeta^2}\Omega = 0, \Omega' \equiv \frac{d\Omega}{d\varsigma} \quad \nu = \nu_E, \text{ is the kinematic viscosity} \tag{3}$$

where the new variable $\boldsymbol{\zeta} = \dfrac{r^n}{2(\nu t)^{\frac{n}{2}}}$ and angular speed $\boldsymbol{\Omega} = \boldsymbol{\omega t}$ are dimensionless, and along with $\boldsymbol{n = 1, 2\ 3}$ which is a dimension index.

Physically, Eq. 2 describes the evolution of stages of rotational energy for the starting vortex (concentrated vorticity) of a gravitational nature, $\boldsymbol{\Omega(\beta g)}$, depending on the space-time variable (a reduced frequency) ζ, that is the base space or age of vortex.

Since a priori the onset of a relative motion, the energy-momentum tensor in the genuine gravitational wave field is zero, then the local post-contact tensor evolves into a succession three Ω-shape stages as the age of vortex (index *n* in Eq. 3) increases early age (*n* = 1), medium stage (*n* = 2) and old (*n* = 3) stage.

The stages of evolution of the impact energy-momentum tensor, viewed as horseshoe or hairpin vortices [18], depend on the initial conditions, Ω_0 (β = 1/3, 1/2, 2/3) and Ω_0' (*n* = 1, 2, 3) of Eq. 3, corresponding to each age *n*, Fig. 1.

In fact, Eq. 3 is an evolution equation that can be used to simulate easily, reliably and accurately different evolving complex physical systems if a gauge (gravitational calibrating) choice is truth.

The each age change at $\zeta = 3, 5$ and 7 involves geometric orientability (n) and energy mutations, that is, structure changes, according to physical applications.

The evolution of the vortex from Fig. 1 shows three transition regimes, associated with geometry and energy mutations, this is, change in the origin structure of vortex (dotted curve).

In subcritical transition regimes for ages $\zeta < \zeta \equiv \log(g\mathrm{Re}_{cr}) = 6$ (early and medium stages), under the action of an impact/contact pressure, $\Delta p/p_c$, depending on (βg) via n (1, 2, 3), an osmotic process is triggered off, usually associated with wave-like disturbances of a gravitational nature.
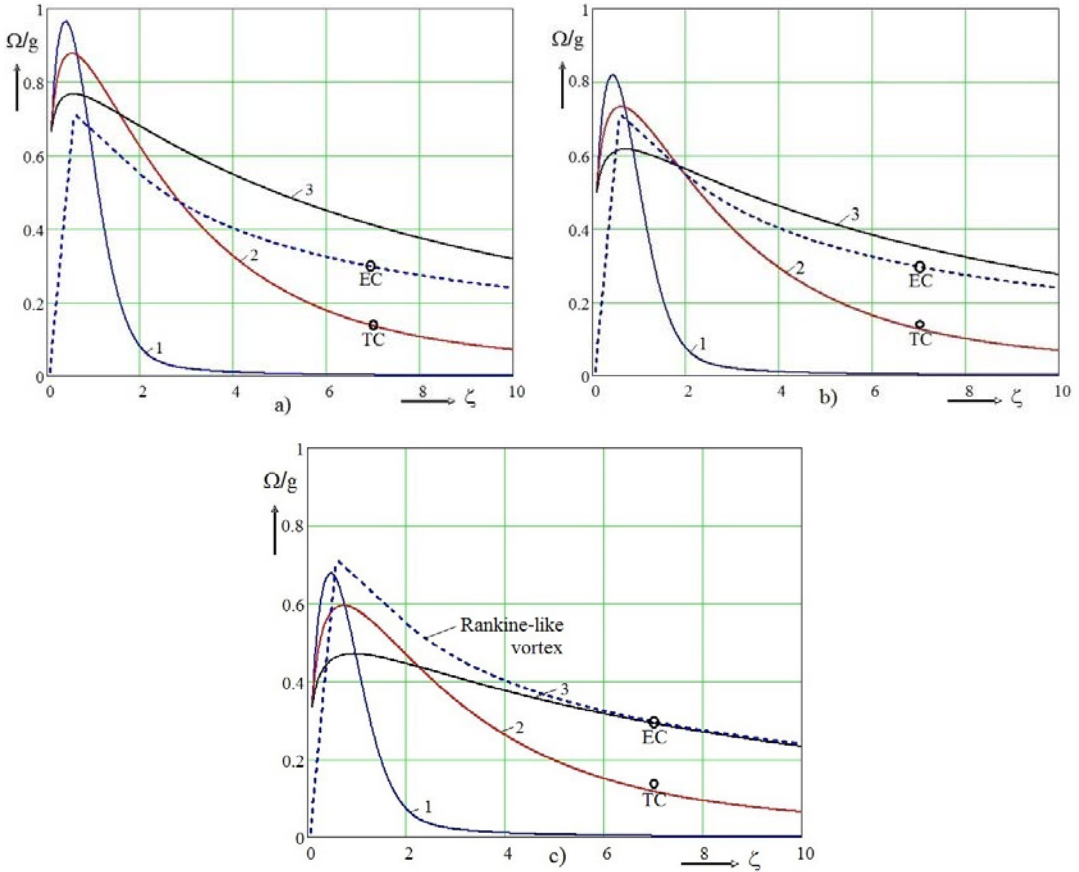

Figure 1. – The evolution stages of a starting vortex, Ω/g, versus the space-time parameter ζ for: a) $\Omega/g = 2/3$, b) $\Omega/g = 1/2$, c) $\Omega/g = 1/3$, and three stages/ages: 1–early stage, 2–medium stage, 3–old stage

The gravitational-shear waves are soliton-like coherent structures that propagate in mass as transverse inertial wave packets of kinetic trinity/ entity (power, kinetic energy and momentum).

The regimes at $\zeta = 3, 5$ and 7 correspond with an osmotic equilibrium for different applied pressures ($\Delta p/\rho = \frac{1}{2} V^2$) where the regimes (3, 5) are diffusions ones, mathematically described by dissipative soliton-like structures [15].

For the supercritical regimes in medium stages ($n = 2$), $\boldsymbol{\zeta \geq \zeta_{cr}}$ at $\boldsymbol{\Omega/g \simeq 0.2}$ (twist center, TC), where the origin vortex suddenly switches in an opposite direction, the violent relaxation of vortex is produced concomitantly with the change into the stage (3) and its dispersion, known as decay of trailing vortices. These regimes termed "structured shear turbulence", visualized as hairpin vortex-coherent structures [19], are a kind of dispersive

Korteweg-de Vries-like solitons describing the evolution of energy-momentum tensor until the isotropic state of stress is restored after the starting impact, Fig. 2. Further the evolution model described above is applied to analyze two contact systems characterized by quantities that fluctuate in an apparent disordered manner with extremely sharp and irregular space-time variations: shear turbulence and pandemics.

3. APPLICATIONS

3.1 Structured shear turbulence

In contrast to Kolmogorov's phenomenology [20] that disregards the origin and the details of the mechanisms of the turbulence production and sustainment, our approach considers that the aspects of the time evolution are of central importance since turbulence dynamics is a process but non just a local one. Thus, this holistic relativistic approach is a path leading from causes (starting of relative motions) to effects (reaction to their onset), based on the Gaian universal self-regulation process for any gravitational disturbance.

The concentrated boundary vorticity (CBV whose evolution has just been shown), is the backbone of structured turbulence, where for starting conditions given $(Re > 10^6)$ the self-gravitational space-time waves penetrate as dispersive soliton-like coherent structure into a large scale macro-fluid view as meaningless and structureless turbulence, until the starting energy-momentum tensor tends to zero.

The evolution of such a dispersive soliton-like coherent structures are termed "structured/ Lagrangian turbulence", universal valid for all turbulent bounded wall flows.

The osmotic process through which the gravitational space-time waves penetrate in cascade as the inertial/ material waves of a kinetic trinity/ entity, that is, power, kinetic energy and momentum, into a macro-flow field, viewed as the random turbulence, yields the initial and boundary accurate conditions for the vast differential theoretical approaches of fluid flows including turbulence. These general initial and boundary conditions for the continuous fluid flows, termed "the contact hydrodynamics", refer to the evolution of inertial waves or kinetic trinity, that is, ordered microscopic flows, versus the starting osmotic pressure and a wave drag for a given circulation, Re, herein the Reynolds number is a measure of flow fluidity. The main relativistic parameters of flowing fluids are used:

- the Richardson number $Ri \equiv \beta g / \left(\frac{dV}{dy}\right)^2$, a starting parameter defined as the ratio of the potential/gravitational energy to the energy recovered from a shearing contact fluid;

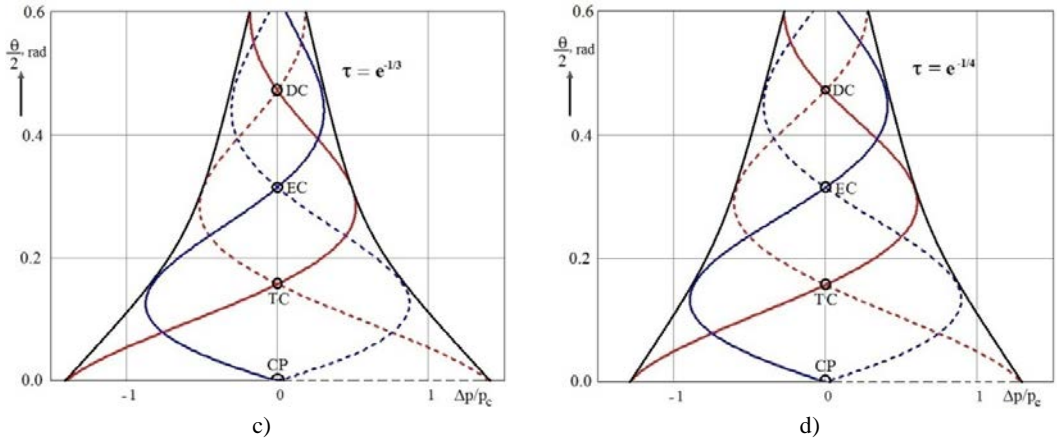a)   b
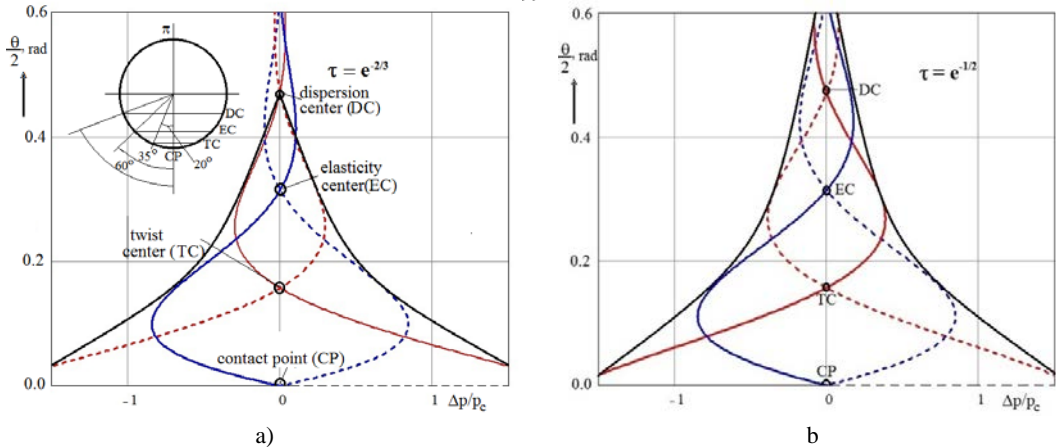
Figure 2. – Structured turbulence/rotary dispersion - the penetration of transverse kinetic waves packet into large scale macro-flow versus CBV (gravity germ of contact structure): a) violent/severe turbulence (ζ=6); b) mild turbulence (ζ=7); c) soft turbulence (ζ=8); d) isotropic turbulence (ζ=9)

- the Mach number, $M \equiv \dfrac{V}{a}, (a = \sqrt{\gamma \dfrac{p}{\rho}} = \sqrt{\gamma RT}, \gamma = 1.4$ for air), is the impact to sonic velocity ratio, and

- the Reynolds number, $Re \equiv \dfrac{Vl}{\nu}$, is the moving fluid to Earth circulation ratio, the intrinsic laws of the contact hydrodynamics for the kinetic trinity can be expressed as Fig. 3 [2]:
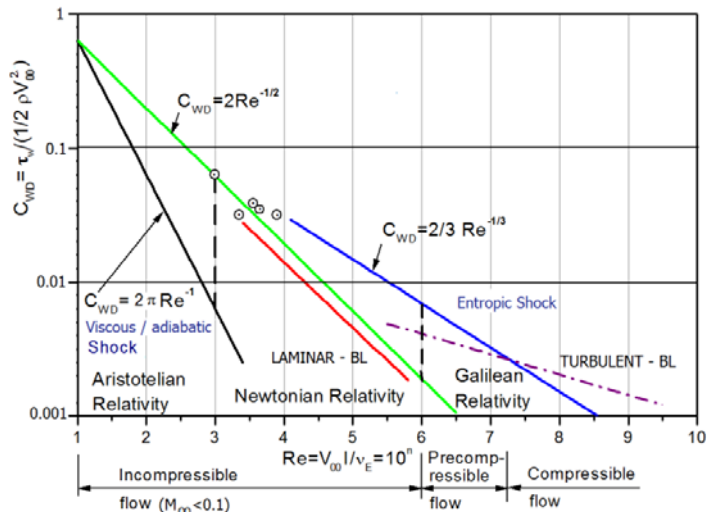
1) the law of circulation

$$\Pi_\Gamma \equiv \frac{p_c - p_0}{1/2\rho V^2} = C_{WD} = 2\pi Re^{-1}, \tag{4}$$

2) the law of kinetic energy-momentum

$$\Pi_K = C_{WD} = 2Re^{-2}, \tag{5}$$

3) the law of kinetic trinity, that is, reactive power, kinetic energy and momentum,

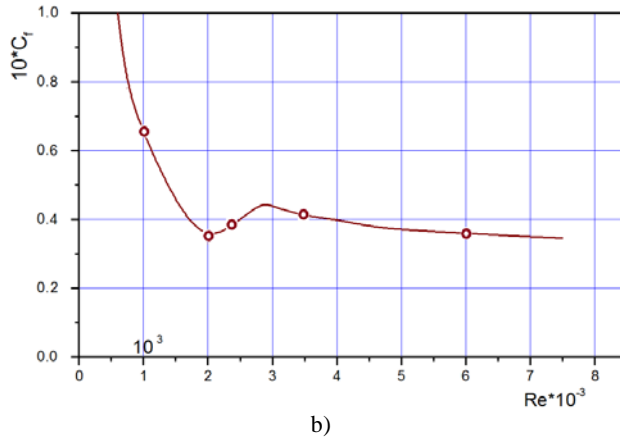$$\Pi_W = C_{WD} = 2/3 Re^{-1/3}, \tag{6}$$

a)

b)

Figure 3. – The self-equilibrating lines of external forces: a) wave drag (skin friction) coefficients,
b) turbulent flow at $Re \simeq 2700$ (water in a circular pipe).

where the dimensionless pressure Π is a reduced osmotic pressure and the osmotic coefficient C_{WD} holds the skin friction/wave coefficient. The first two laws corresponds to Kelvin's circulation theorem and Bernoulli's equation [4], while the third law of power for structured turbulence replaces the empiric Prandtl's wall laws
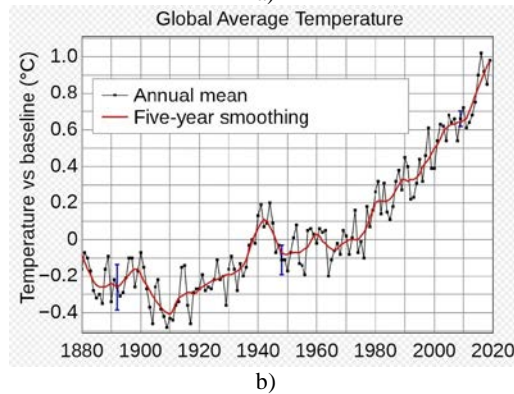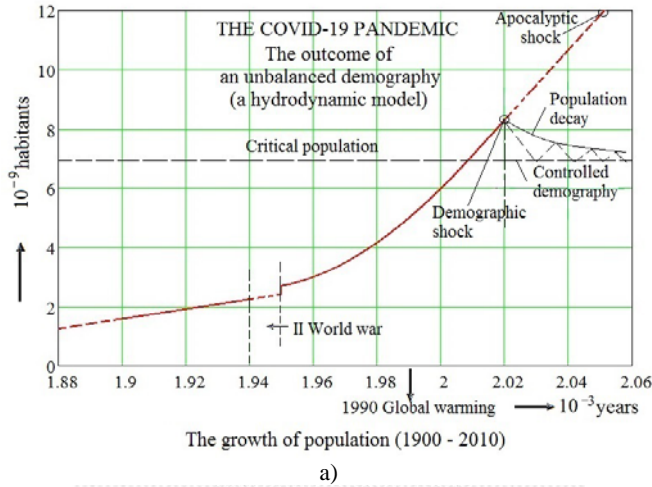

a)

b)

Figure 4. – The mutual effects - causes of excessive usage of the Earth's potential energy:
a) growth of population; b) global average temperature

for turbulent flows. In fact the laws of contact hydrodynamics are reference formulae that permit quantitative comparison with experiments and numerical simulations.

3.2 World population and its malady (covid-19 pandemic)

Apparently, the examples chosen to illustrate the evolution of these processes have nothing in common. However, if their beginning is near instantaneously of a shock kind, then this involves quantities that fluctuate in a disordered manner with extremely sharp and irregular
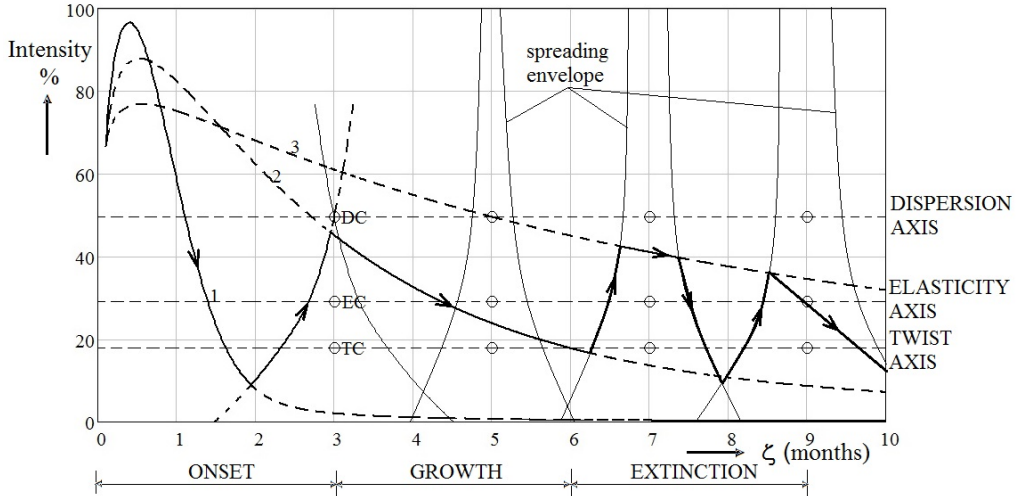

Figure 5. – The evolution/route in cascade of a pandemic process

space – and time – variations like turbulence and pandemic phenomena.

Many similarities between the evolutions of these phenomena come from that both are behaviors of the complex Earth-bound system when its timeless steady work is strongly perturbed, and the turbulence by high starting accelerations is involved, while the pandemic is an Earth-bound reaction to the excessive exploitation of its internal-like oil and external-like intensive agriculture resources. In the case of turbulence, this kind of reaction is reflected by the usual Newton-Galilei law of equal action and reaction for stress vector and/or tensor.

But, in the case of pandemics much later it was noted that the planet Earth as a living/active surface has a self-regulation property of interaction between organisms known as the Gaia hypothesis. If for the Spanish flu pandemic (1918) nobody could relate it to the beginning of intensive exploitation of oil (Gaian self-regulation idea being promoted by J. Lovelock (1972) and L. Margulis (1974) [21], [22], some decades after, V. Vernadsky [23] formulated a theory of Earth's development), for today the actual pandemic can be viewed as feedback mechanisms that evolve from the human actions or activities, Fig. 4.

Figure 4 shows that the energy budget of a populated planet (almost 10^8 habitants), exceeds the potential energy associated with the global warning, usually seen as abnormal climatic changes, and misunderstood population pandemics seen as a disaster rather than a gravitational field strongly perturbed/ disrupted by abusive human behavior.

Based on the above generating vortex model, along with a gravitational Gaian-like self-regulation process, a scenario for the evolution of the pandemic–like COVID-19 is proposed. Figure 5 shows a development in cascade along with three stages and each period of three months, but the process can turn out after six months if its causes are removed.

The Earth-planet by means of gravitation waves herein under the form of pandemics usually accompanied with job/ food crises, defends itself own natural energy against human

actions. Paraphrasing Malraux**, the actual century has to be a rational/scientific one, or it will not be**, see Fig. 4a.

4. CONCLUSIONS

Based on the mathematical concepts of contact geometry, that is, fibre bundle and gauge connection, a holistic approach of the contact hydrodynamics has been proposed, including turbulence. In contrast to the previous opinions stating that the turbulence represents random, structureless and meaningless motions, our holistic relativistic approach has shown that the origin and structured turbulence are the outcome of an evolution stage of the starting process as a whole, for certain given conditions of flowing fluids. Since the onset of a pandemic process is a kind of shock as is the turbulence process, its evolution model has been applied to predict the evolution of COVID-19, where results consistent with the observations in situ were found. Both processes are governed by the gravitational waves, where their energy is near half of potential energy of the Earth with emergent multiple reactions.

Besides, the present paper yields a scientific explanation for the previous Gaia hypothesis that must become a "Law" itself over a more accurate space that is the variable gravity Galilean tensor space different from the constant gravity Newtonian vectorial space.

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