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Appendice 3

Toward One Sole Reference Principle Generating "Emerging Solutions" of progressively ascending Ordinality

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ABSTRACT

In a previous paper (Gainesville 2010) I already pointed out that the Maximum Em-Power Principle would "manifest its true relevance mainly in the future, and for many years to come. This is because "the real and effective introduction of a renewed concept of Quality in Science is able to transform any scientific aspect", including the same Classical Thermodynamics.

The "Emergy" concept, in fact, when understood as "Energy memory" of both the specific structure of the Basic Processes (Co-production, Inter-action, Feed-back) and their corresponding cardinal reflex (Rules of Emergy Algebra), can be expressed by means a new formal entity: the incipient derivative, characterized each time by a specific Ordinality. In this way such a new formal concept is able to unify, by itself, the two previous concepts under dynamic conditions too.

On these bases the Maximum Em-Power Principle was reformulated (Gainesville 2012) as the Maximum Ordinality Principle, by adopting the same formal description to model any System, understood as a Whole, and characterized by a given comprehensive Ordinality.

Such a reformulation then allowed us to consider several applications (synthetically described in the paper), which clearly show that the Maximum Ordinality Principle may be adopted as a Unique and Sole Reference Principle.

This is because it appears as being valid: i) in any field of analysis (from non-living Systems, to living Systems and also human social Systems (e.g. Economics); ii) at any scale of analysis (from atoms and molecules up to Galaxies); iii) under steady state and dynamic conditions; iv) and, in particular, without any reference to specific Physical Laws or to the well-known Thermodynamic Principles.

INTRODUCTION

Modern Science is characterized by a progressively ascendancy toward ever more general Physical Laws and Principles: i) from Kepler's Phenomenological Laws; ii) to Physical Laws understood in the proper sense of the term, such as, Newton's Laws, Maxwell's Equations, etc.; iii) up to the well-known three Principles of Thermodynamics. A progressive development that originated a *quantitative* hierarchy of Physical Laws and Principles.

In 1994, however, the enunciation of the Maximum Em-Power Principle on behalf of Prof. H. T. Odum, introduced a radical novelty in such a hierarchy. This Principle, in fact, represents the foundation of a new approach to Thermodynamics, which could be termed as "Thermodynamics of Quality".

THE RADICAL NOVELTY OF THE MAXIMUM EM-POWER PRINCIPLE

The Maximum Em-Power Principle (Odum H. T., 1994a,b,c) introduces a profound novelty with respect to Classical Thermodynamics precisely because it is based on a radically new gnosiological perspective, which recognizes that: "*There are processes, in Nature, which cannot be considered as being pure* "*mechanisms*".

Such an assertion is equivalent to saying that they are not describable in mere functional terms, because their outputs show an unexpected "excess" (with respect to their pertinent inputs). Such an "excess" can be termed as Quality (with a capital Q) exactly because it is no longer understood as a simple "property" or a "characteristic" of a given phenomenon, but as being any *emerging* "property" (from the considered process) *never ever reducible* to its phenomenological premises or to our traditional mental categories (Giannantoni, 2009; see also Anderson, 1972).

This led Prof. Odum to consider three fundamental Processes (Co-production, Inter-action and Feed-back), schematically represented in Fig. 1, and to introduce a new physical quantity, Emergy and an associated *non-conservative* Algebra (valid in steady-state conditions) (see Brown & Herendeen, 1996), in order to describe their "generative" behavior.

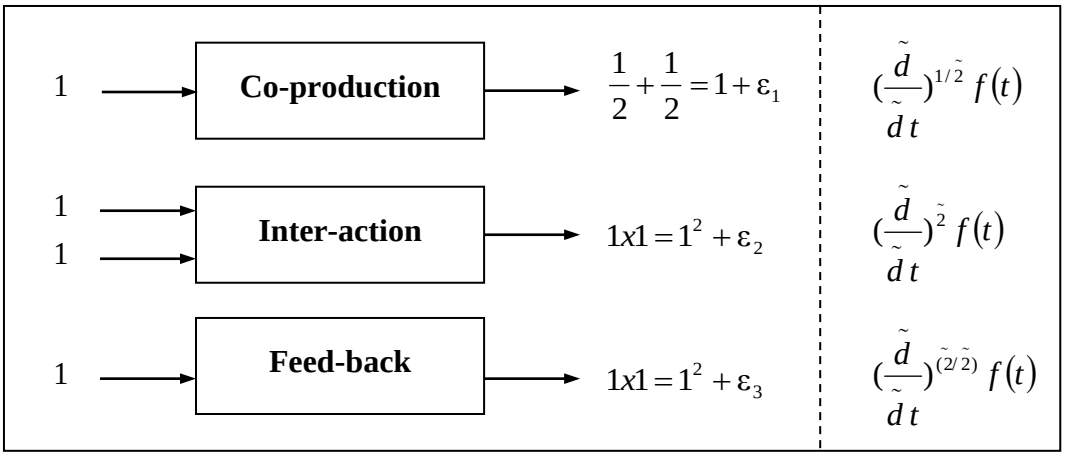

Fig. 1 - The output "excess" as a "cipher" of the internal self-organizing activity of the System and its formal representation under Dynamic Conditions in terms of "incipient" derivatives

If we consider in fact the Rules of Emergy Algebra pertaining to the three fundamental Processes (Co-production, Inter-action, Feed-back) schematically represented in Fig. 1, we can easily recognize that the *non-conservative* Algebra adopted substantially asserts that: i) "1 + 1 = 2 + something else" (in a Co-production); ii) whereas "1 times 1 = 1 + something extra", where this "extra" strictly depends on the nature of the Process (Inter-action or Feed-back, respectively). In this sense such an "excess" can be interpreted as a "cipher" of the internal self-organizing "activity" of the System (where the term "cipher" is here understood in a gnosiological sense).

It is then evident that, when transforming such a non-conservative Algebra (generally valid in steady-state conditions) to *dynamic conditions*, we end up by introducing a corresponding *non-conservative* Differential Calculus (the corresponding transpositions of the Rules in terms of "incipient" derivatives are shown on the right hand side in Fig. 1). This is precisely because the traditional derivative is not properly apt to represent such a "generative" behavior.

The Mathematical Formulation of the M. Em-P. Principle given in terms of Incipient Derivatives (Giannantoni 2001b, 2002), and the successive applications of the same in several different fields, during the period 2002-2009 (see, among others, Giannantoni 2004a,b, 2006, 2007, 2008a,b, 2009a,b), suggested a possible reformulation of the M. Em-P. Principle as the Maximum Ordinality Principle (Giannantoni 2010a).

THE MAXIMUM ORDINALITY PRINCIPLE

The basic idea of such a reformulation is very simple. In fact, it is nothing but the formal translation of the following "emerging" syllogism:

i) If any self-organizing System can always be thought of being structured on the basis of the three above-mentioned fundamental Processes;

ii) and each one of the latter can be modeled in Generative terms by means of an Incipient Derivative, characterized by its specific Ordinality (see Fig. 1);

iii) It should also be possible, in a perfect analogy, to model any System, in Generative terms, as a Whole, by means *one sole* Incipient Derivative, characterized by a specific and appropriate Ordinality. That is

$$(\tilde{d}/\tilde{d}t)^{(\tilde{m}/\tilde{n})}\{\tilde{r}\}_s = 0 \qquad (\tilde{m}/\tilde{n}) \to Max \tag{1}$$

where: $(\tilde{d}/\tilde{d}t)$ is the symbol of the incipient derivative; $(\tilde{m}/\tilde{n})$ is the Ordinality of the System, which represents the Structural Organization of the same in terms of Co-Productions, Inter-Actions, Feed-Backs; while $\{\tilde{r}\}_s$ is the proper Space of the System (see Giannantoni 2010a, 2012).

This is precisely the reason why the Principle was renamed as the Maximum Ordinality Principle. Its corresponding enunciation then becomes: "Every System tends to Maximize its own Ordinality, including that of the surrounding habitat".

In this form, the Maximum Ordinality Principle always presents explicit solutions, which re-propose, under dynamic conditions, the same properties of the non-conservative Emergy Algebra. Its solutions, in fact, can better be termed as "Emerging Solutions" (see also Appendix), precisely because *they always show an Ordinal Information content which is much higher than the corresponding content of the initial formulation of the Problem*.[1]

In this respect we can surely assert that: if the introduction of a *non-conservative* algebra, on behalf of Prof. Odum, represents one of the major novelty in Mathematics in the last 400 years, the "Emerging Solutions" represent their corresponding novelty in the field of Differential Calculus.

The Maximum Ordinality Principle, first presented in (Giannantoni 2010a), and in its more general form in (Giannantoni 2012), can thus be considered as the reformulation of the Maximum Em-Power Principle as a consequence of the following three logical passages: i) the introduction of the concept of Generativity; ii) its formal representation by means of the concept of "incipient" derivative (Giannantoni 2001a, 2002, 2004, 2008, 2009b); iii) its direct application to the Whole System, considered as being characterized by a specific and appropriate Ordinality.

From a mathematical point of view, Equation (1), considered together with its associated initial conditions, leads to the following explicit Solution, here represented in its most general "emerging" form (Giannantoni 2012)

$$\{\tilde{r}\}_s = e^{\begin{Bmatrix} 0 & \tilde{\alpha}_{12}(t)\oplus\tilde{\lambda}_{12}(t) & \dots & \tilde{\alpha}_{1N}(t)\oplus\tilde{\lambda}_{1N}(t) \\ \tilde{\alpha}_{21}(t)\oplus\tilde{\lambda}_{21}(t) & 0 & \dots & \tilde{\alpha}_{2N}(t)\oplus\tilde{\lambda}_{2N}(t) \\ \dots & \dots & \dots & \dots \\ \tilde{\alpha}_{N1}(t)\oplus\tilde{\lambda}_{N1}(t) & \tilde{\alpha}_{N2}(t)\oplus\tilde{\lambda}_{N2}(t) & \dots & 0 \end{Bmatrix}} \tag{2},$$

where N is the number of the elements of the System and $\tilde{\lambda}_{ij}$ represent some *internal reciprocal* Correlating Factors, which satisfy an additional "*emerging*" *property*, expressed by the following Harmony Relationships:

[1] They in fact represent the formal translation of the holistic enunciation: "The Whole is more than its parts".

$$\tilde{\alpha}_{1j} \oplus \tilde{\lambda}_{1j}(t) \overset{*}{=} \tilde{\alpha}_{12} \oplus \tilde{\lambda}_{12}(t) \qquad \text{for } j = 3,4,.....N \tag{3}$$

together with all their associated *incipient* derivatives, up to the order N-1

$$\{\overset{\circ}{\tilde{\alpha}}_{1j} \oplus \overset{\circ}{\tilde{\lambda}}_{1j}(t)\}^{\tilde{k}} \overset{*}{=} \{\overset{\circ}{\tilde{\alpha}}_{12} \oplus \overset{\circ}{\tilde{\lambda}}_{12}(t)\}^{\tilde{k}} \qquad \text{for } k = 1,2,.....N-1 \tag{4}.$$

This means that all the elements of Ordinal Matrix (2) can be obtained on the basis of 1 sole couple $\tilde{\alpha}_{ij}(t)$ assumed as reference and N-1 associated Correlating Factors. In this respect it is also worth noting that conditions (3) and (4) define what could better be termed as an *Intensive Whole*, because of the "consonance" between all the generative derivatives up to the order N-1.

On the basis of such a Mathematical Formulation of the M. O. P. we have then reconsidered some "special" problems, generally known in literature as being "unsolvable", "intractable", "with drift", whose solutions ended up by showing that such a Principle seems to have an extremely general validity.

"UNSOLVABLE", "INTRACTABLE" AND "DRIFT" PROBLEMS IN THE LIGHT OF THE MAXIMUM ORDINALITY PRINCIPLE

"Unsolvable" Problems

These Problems are termed as such precisely because they do not present an explicit solution, often not even in a "closed form", when dealt with in terms of TDC (Traditional Differential Calculus). Let us consider first the most famous among them:

i) The Three-Body Problem, already dealt with in terms of Incipient Differential Calculus (IDC) albeit in a Newtonian context (Giannantoni 2007, ch. 5), it presents a more elegant solution when analyzed on the basis of the M. O. Principle. In particular, and for the sake of generality, in the context of the entire Solar System (made up of 11 bodies, if we include the asteroid belt too).

In such a case, the "correlation factors" $\tilde{\lambda}_{ij}$ that appear in the Ordinal Matrix (2), as well as in the Harmony Relationships (3) and (4), precisely represent that "Extra" which leads us to the explicit solution to the problem. A contribution "Extra" whose presence, vice versa, can never be recognized if Energy is assumed as being constant (as usually happens). This is precisely because, as explicitly pointed out by the same E. Poincaré, "The conservation of Energy is a limitation imposed on the *freedom* of complex systems." (Poincaré, 1952, p. 133). In other terms, Energy conservation excludes *the emergent novelty* that grows out of complex interactions (see also Mirowski, 2000, p. 5).
The general solution obtained for the entire Solar System (Giannantoni & Rossi, 2014), enabled us to give an appropriate answer to some other related problems:

ii) The distribution of the Planets in the Solar System
As is well known, the characteristic dimensions of the planetary orbits are approximately described by the semi-empirical Bode Law (with the exception of Neptune and Pluto). Up to now, however, there is no physical reason able to explain such a topological distribution, that is: the fact that the ration between the successive mean distances between the Sun and the various Planets (including the "asteroid belt") are approximately "constant", within 15% (always with the exception of Pluto). The M. O. P., vice versa, is able to furnish an "Emerging Solution" (see Eq. (2)) which fits quite well the afore-mentioned distances, considered at any given time t_0. The pertinent "cardinal" values corresponding to such an "Emerging Solution" were obtained by means of an appropriate Computer Simulator termed as "EQS" (Emerging Quality Simulator), which reproduces Eq. (2).

This allows us to underline a very important aspect. In fact, apart from the possibility of obtaining in this way a more appropriate "trend" with respect to astronomical data, it is even more important to point out the fact that the "Emerging Solution" so obtained is able to show the

effective reason why it has been impossible, up to now, to find the physical "foundation" of Bode's Law.

The fundamental reason resides in the fact that the Solution obtained can never be "reduced" to mere functional terms, precisely because is an "Emerging Solution". On the contrary, both Classical Mechanics and General Relativity intrinsically tends to research for a mere functional relationship.

In addition, the "Emerging Solution" obtained clearly shows that the *space* between Planets is not a "topological" concept defined *a priori* (a sort of "container" in which the Planets are placed), but it is the manifestation of that Relation Space which is generated by the same bodies, precisely because they are "parts" of a "unique and sole" Generative System.

iii) The angular distribution of planetary orbital planes with respect to the Ecliptic

This is another example in which there is no satisfactory physical explanation of such a distribution. The main reason fundamentally depends on the fact that, in the absence of any explicit solution to the "Three-body Problem", it is impossible to evaluate the exact influence between the reciprocal orbits of the Planets. The various angles, in fact, are distributed in a cone of a rather large width (20°), which reduces to 10° if the extreme Planets (Mercury and Pluto) are "excluded" (this is because, as usual, the latter are recognized as being rather "anomalous").

In reality, also in such a case, the M. O. P. (through its associated "EQS") is able to furnish a satisfactory distribution of the afore-mentioned angles. What's more, such a distribution, which is still an "Emerging Solutions", is contextually obtained together with the previous one.

As an immediate consequence, the two afore-mentioned "Emerging Solutions" (pertaining to distances and angles respectively) can be "seen" as one sole "Over-Emerging Solution", which could also be termed as an "Inflorescence" of Emerging Solutions generated by the M. O. P..

iv) The angular velocities of Stars in Galaxies and the related hypothesis of "Dark Matter"

The unexpected non-Keplerian distribution of velocities inside any Galaxy (each one generally made up of $50 \div 100 \cdot 10^9$ Stars) led Scientists to suppose the presence of a "non-visible" matter (thus denominated "dark") that could explain such a unexpected behavior. This is because such a phenomenology results as being unforeseeable, and also inexplicable, on the basis of both Classical Mechanics and General Relativity.

Vice versa, on the basis of the M. O. P., it is rater easy to show that, apart from a very limited area near the center of the Galaxy, we always have

$$\rho_{1j}(t) \cdot \overset{\circ}{\varphi}_{1j}(t) \cong \cos t \qquad (5),$$

where $\rho_{1j}(t)$ and $\overset{\circ}{\varphi}_{1j}(t)$ represent the "distance" and the angular velocity, respectively, of any given star (j) with reference to star "1", that is the nearest one to the "Center" of the Galaxy.

The profound difference between Eq. (5) and the more common Keplerian trend, represented by

$$\rho_{1j}(t) \cdot \overset{\circ}{\varphi}_{1j}(t) \cong \cos t / \sqrt{\rho_{1j}(t)} \qquad (6),$$

may clearly explain the "subjacent" reasons that lead Scientists to formulate the hypothesis of "Dark Matter".

The same comparison, on the other hand, is also able to show the wide "flexibility" of the M. O.P., in particular when passing from 11 bodies (Solar System) to $50 \div 100 \cdot 10^9$ bodies of a Galaxy.

v) The Three-good two-factor problem in Economics

The possibility of transposing an "Emerging Solution" from a given context to a completely different field of analysis (see later on) led us to face such a well-known "unsolvable" problem in Economics.

The explicit solution to this problem was obtained as a particular case of the solution to the "Three good, two factor Problem", which represents the direct transposition to Economics of the "Three-body problem" in Classical Mechanics (Giannantoni 2011b). Afterwards, on the basis of

the afore-mentioned “flexibility” of the M. O. P. , the problem was also generalized to the case of “N-good three factor problem” (ib.).
We can now consider the case of “Intractable Problems”.

“Intractable” Problems

The above-mentioned possibility of transposing a given solution from one context to another field of analysis (see later on) led us to deal with some well-known “intractable” problems. For instance, the famous “Protein Folding” in Biology.

i) Protein Folding

The fundamental importance of the Protein Folding Process is widely recognized, both in Medicine and Pharmacology. It is also well-known, however, that it is one of the dynamic problems considered as being maximally intractable. In fact it usually requires about 10.000 years even if run on the most updated computers (1 Petaflop). In addition, even in the case of solutions obtainable in reasonable computation time, these always present a “drift” between the foreseen behavior of the biological system analyzed and the corresponding experimental results. A drift which is much more marked as the order of the system increases. (Giannantoni 2010b, 2011a).
Both the “intractability” of the problem and the above-mentioned “drifts” can be overcome on the basis of the Maximum Ordinality Principle.
In fact, the solution to the “Three-body Problem” previously obtained and its subsequent extension to any number of bodies, allows us to assert that the folding of even a macroscopic protein, such as dystrophin for example, which is made up of about 100,000 atoms, can be carried out in a few minutes, even when the model is run on a simple PC, characterized by a much lower computation power (1 Gigaflop). This is mainly due to the already mentioned profound “symmetry” properties of the Ordinal Matrix in Eq. (2), which are faithfully reproduced in numerical terms by EQS.

ii) Exon Skipping in DMD (Duchenne Muscular Dystrophy)

This represents an example of Ordinal Inter-Action between two distinct biological compounds, finalized to improve the production of an efficient Dystrophin in children who suffer from such a severe pathology, as a consequence of a genetic mis-folded Dystrophin.
The Inter-Action Process can be described as follows: on the one hand there is a selected inefficient Exon (that is one out of the 80 parts in which Dystrophin is usually subdivided) and, on the other hand, an artificial biological compound termed as AON (Antisense Oligo-Nucleotide), able to “isolate” (or better, to “skip”) the considered inefficient Exon pertaining to the mis-folded Dystrophin.
Both Exons and AONs are made up of the four fundamental Bases (Adenine, Cytosine, Guanine, Tymine). However, while any Exon is constituted by 180-200 Bases, any AON, vice versa, is made up of 20-30 Bases.
The theoretical approach to such an Inter-Action Process presents the same limitations as previously recalled in the case of Protein Folding.
Hoverer, if such an Inter-Action is analyzed in the light of the M.O.P. (and its associated “EQS”), the appropriate results can be obtained in less than 2 seconds, on a simple PC. (see Reports to Leiden University, June 6 and December 12, 2013). It then becomes very easy to recognize the reason why some AONs are potentially more efficient than others. An aspect that, apart form the associated benefits when adopted in a therapy, it can lead to a significant acceleration in the research of the most appropriate AONs, by also saving time and costs associated to a reduced number of preliminary experimental tests (“in vitro” and “in vivo”).
The results concerning this methodology have been obtained through a collaboration with Leiden University, that specifically works on this field, and that supplied the experimental data needed to feed the “EQS” previously mentioned, now applied to the “Exon Skipping” Process.

iii) Molecular Docking, **Drug Design and Protein-Protein Interaction**

The methodology developed with reference to Exon Skipping Inter-Action was conceived, from the very beginning, in such a way as to be also directly adopted in the case of both **Molecular Docking** and computer-aided **Drug Design**, by means the same “EQS” already developed.

In such a context it is also worth mentioning, in a special way, the further possibility of analyzing, on the basis of the same approach, the **Protein-Protein Interaction Process**, which represents the fundamental basis for any form of advanced Pharmacology.

Problems with "drift"

This expression would synthetically indicate those problems in which there is a "disagreement" (thus termed as "drift") between the foreseen behavior of the System modeled on the basis of the traditional Physical Laws and Principles with respect to the corresponding experimental results.

i) Precessions of Planets

The case of Mercury's Precession was initially dealt with in a Newtonian context in terms of incipient derivative by simply considering the Sun and Mercury as a single (and isolated) couple of bodies (Giannantoni 2007, ch. 4).

Now, on the basis of the M.O.P. (and its associated EQS), the differences between the various planetary "precessions", and also their "variations" in time, result as being a *unique* evolutionary "Emerging Solution". The general model, in fact, is perfectly analogous to that adopted in the case of both "distances" (from the Sun) and "angles" of the orbital planes (with respect to the Ecliptic) previously presented. The only difference is that the latter were obtained with reference to a given time *t* and, as such, they "update" Third Kepler's Law.

Such a new "Emerging Solution", in fact, is not only able to show the *generative* origin of such a phenomenon, but also points out that the values predicted by General Relativity (GR) for the various Planets cannot be considered as a definitive answer to this problem. This is because: i) the time intervals considered in GR are too limited for an appropriate answer; ii) in addition, the analysis is always limited to the case of a "Two-body Problem"; iii) consequently, the results obtained do not account for the contributions due to the Solar System understood as a Whole.

All these aspects are strictly related to the fact that General Relativity is not able to solve the "Three (or more)-body Problem", precisely because of its intrinsic "functional" approach.

What's more, when the "Three-body Problem" is faced in numerical terms (in the context of GR), the solutions proposed by Sundman (1912) and Wang (1990s) become even more "intractable" than in the case of Classical Mechanics. In this case Processions of Planets, which are basically problems with "drift", also become, at the same time, "Intractable" Problems when faced in the context of the entire Solar System.

ii) Intrinsic Instability of Smart Grids

The Protein Folding problem previously recalled, in particular when referred to Dystrophin (that is the longest protein in a human body, made up of 100.000 atoms), suggested the possibility of analyzing, on the basis of the same M. O. P., the well-known Instability of Smart Grids.

In fact, when a Smart Grid reaches the number of about 100.000 plants (or more), it may present some forms of instability. The latter are generally associated to a distortion "drift" (with respect to a perfect sinusoidal trend) which tends to amplify even under normal exercise conditions, as a consequence of the different currents produced by its *N* generators. This is because of the differentiated time increases (or decreases) in the electrical charges to be supplied. A "drift" that, in addition, becomes even more marked in the case of a cyber attack.

On the contrary, when a Smart Grid is designed according to the M.O.P., the corresponding Maximum Stability conditions can always be assured. This is because the various plants are connected to each other in such a way to satisfy the afore-mentioned Harmony Relationships (3) and (4).

The corresponding "Emerging Solution" (2), in fact, can evidently be generalized to any kind of exercise conditions. This means that the considered Smart Grid can always be controlled in such a way as to work at its Maximum Ordinal Stability, not only under normal exercise conditions, but also in the case of cyber attacks.

This is because Eq. (2), understood as an "Emerging Solution" to the mathematical model of a Smart Grid, is able to foresee, in explicit terms, the corresponding phenomenological "Exits" (see Giannantoni 2012) of the physical System analyzed. This offers some important advantages: i) the possibility of optimizing the exercise conditions of any Smart Grids already realized; ii) the

possibility of improving the design of any new Smart Grids to be realized; iii) in both cases, not only as far as the intrinsic stability of the Grid is concerned, but also (and especially) with reference to external disturbances (such as, for instance, cyber attacks). (ib.).

iii) The "Unexplained" Sea Level Rise Over The Period 1900-2000

Global sea level has been rising at a rate of around 1.8 mm per year (i.e. 18 cm/century). This rate is still increasing. Measurements from satellite altimetry indicated a mean rate of 3.1 mm/year in the period 1993-2003 (IPCC, 2007). More recent data indicate a value of 3.2 mm/year (WMO, 2013).

The real trend of such an increase has been registered by means of 23 long tide gauge records, in geologically stable environments distributed all over the world, provided by the Permanent Service for Mean Sea Level (2010). Theoretical estimations, on the contrary, lead us to foresee a trend of 6.0 cm/century.

Such a discrepancy represents an "enigma". In fact: "Two processes are involved: an increase of the mass of water in the oceans (the eustatic component), derived largely from the melting of ice on land, and an increase of the volume of the ocean without change in mass (the steric component), largely caused by the thermal expansion of ocean water." (Meier & Wahr, 2002, p. 1).

The eustatic contribution of 6 cm attributed to IPCC leads to a residual rise to be explained of 12 cm to the end of the century, which cannot be accounted for by steric expansion only. (ib.)

On the other hand, other potential effects do not seem to be able to explain such a difference, because they only give marginal contributions. Consequently, they are insufficient to account for the observed drift of 12 cm.

The interpretation of such a difference, preliminarily based on the sole adoption of IDC, has already been given in (Giannantoni & Zoli, 2009). In such a case the corresponding analysis led to a net increase of *not less than* 17.0 cm/century (ib.).

This result shows that the "un-explained" recent sea level rise is due more to an intrinsic limitation of the mathematical models usually adopted to describe physical systems (in terms of TDC) than to new (or not yet identified) causes. This can surely asserted on the basis of the fact that the obtained results do not refer to (foreseen) *future* trends, but concern *past* effects, already registered and accurately measured.

Such results, however, can now be analyzed from a more general point of view, that is in the light of the M.O.P. In particular, by means of its associated Simulator "EQS". The latter in fact is already structured in such a way as to represent the various Interactions between all the physical Systems involved (sea, ice, hearth, sun, etc.). Interactions that represent the real "generative cause" of that registered "unexpected" trend, which thus reveals, in this way, as being an "Emerging Solution".

iv) The intrinsic "drift" of Classical Thermodynamics

The cardinal "drift" of Classical Thermodynamic Principles at "a large scale" has already been presented in (Giannantoni 2010). For the sake of brevity, we will synthetically refer to the "drift" of the (so-called) "Energy Conservation Principle".

Such an aspect, first pointed out in terms of the sole "Incipient" Derivatives (Giannantoni 2002, p. 149, 2007, p. 46), was much clearly shown in (Giannantoni 2010) with reference to Mercury Precessions and, at the same time, with reference to the "unsolvability" of the "Three-body Problem". This also allowed us to point out by the basic reasons that lead Poincaré to assert: "The conservation of Energy is a limitation imposed on the *freedom* of complex systems" (Poincaré, 1952, p. 133).

Now, on the basis of the general formulation of the M. O.P., it is possible to show that "non-conservation" of Energy (at a large scale) can also be shown at the level of the Solar System and, even more, at the level of larger Systems. This analysis clearly reveals that the "drift" of Energy Conservation is directly referable to the recognized expansion of the Universe. A result that led modern Astronomy to formulate the "hypothesis" of "Dark Energy", in order to account for the "unexpected excess".

In the case of "large" Systems, in fact, characterized by high values of *N*, the "correlation factors" $\tilde{\lambda}_{ij}$ in the Ordinal Matrix (2) precisely represent those "corrective" factors that are required to "overcome" the traditional description of the System, usually understood as a simple "sum" of "*functional*" interactions between couples of elements.

In such a perspective, "Dark Energy" exactly represents that cardinal "drift" (with respect to "conservation" of Energy), which is simply due to the gnosiological presuppositions of the traditional approach. These, in fact, systematically, and also *aprioristically*, "filter" any form of Generativity which, vice versa, according to the M. O. P., is ever-present in all "*Phy*-sical" Phenomena. In this respect it is also worth noting (once again) that the "corrective" factors $\tilde{\lambda}_{ij}$ satisfy conditions (3) and (4) and, consequently, they contextually represent an *Intensive Whole*, rather than to a simple "sum" of the single elements of the System.

TRANSPOSITION OF MODELS AMONG PROPER SPACES OF ANALYSYS

In addition to the solutions previously shown, the M.O.P. also allows us the possibility of transposing "Emerging Solutions" already obtained in a given field, to a different field of analysis, by means of a simple transposition of the pertinent Relation Spaces.

Such a possibility, already shown in (Giannantoni 2012), can be realized by adopting a new space of analysis characterized by *three* new "variables" $(\tilde{X}, \tilde{Y}, \tilde{Z})$.

The number of three is here fundamental, because *three* distinct variables enable us to represent, through their Ordinal Relationships, the three fundamental Processes pointed out by Prof. Odum (Co-Production, Inter-Action, Feed-Back). The three new mathematical "variables" $(\tilde{X}, \tilde{Y}, \tilde{Z})$, however, should not be considered as being, by themselves, a sort of "limitation", because, if required, they can also be structured in the form of *Ordinal Matrices*.

THE MAXIMUM ORDINALITY PRINCIPLE AS "ONE SOLE" REFRENCE PRINCIPLE

The Ostensive Examples previously presented, associated with their possible transposition to different fields of analysis, show that there exists a real possibility of adopting the M. O. P. as *one sole* and *unique* Reference Principle for several extremely variegated classes of Systems and Processes.

In this respect, it is fundamental to point out that the considered Ostensive Examples do not only suggest such a particular propensity (of adopting the M.O.P. as one sole reference principle), but they also clearly manifest that the initial hypothesis which led us to formulate the M. O. P. is generally valid: "Every System can always be described by means of an "Incipient" Generativity, characterized by a specific Ordinality".

Contextually, the same Examples also manifest the corresponding "subjacent" reason for such an assumption, that is: "At the root of any Self-Organizing System there is always a Generativity of Ordinal Nature".

This also allows us to better understand the reason why "Every System tends toward its Maximum Ordinality". This is because: i) Generativity is intrinsically characterized by an Ordinal Nature. This means that Generativity is the real "source" of Ordinal Relationships (according to its specific Ordinality); ii) Ordinality, in turn, is the one which really "guides" and organizes" the associated cardinalities, whereas the later represent a simple quantitative "reflex" of the former.

MAIN CONSEQUENCES

The main consequences can be articulated in three parts: i) the proposal of "One Sole Principle" introduces a completely new gnosiological perspective with respect to the traditional scientific approach; ii) the two approaches, however, are not reciprocally "exclusive", because they are always "com-possible"; iii) nonetheless, they lead to two radically different ways of Thinking, Decision Making and Acting.

i) Two radically different approaches

The two approaches could synthetically referred to as (d/dt) and $(\tilde{d}/\tilde{d}t)$ respectively, because the corresponding formal languages synthesize their pertinent pre-suppositions. Their basic radical differences are show in Tab. 1

Table 1 - Basic radical differences between the two considered Approaches

Approach (d/dt)	Approach $(\tilde{d}/\tilde{d}t)$
In this approach: i) any problem requires the adoption of *all* the Physical Laws and Principles involved in the specific field of analysis each time considered ii) together with the consideration of the pertinent "forces" (as an expression of the *efficient causality*), with the associated assumptions of a *necessary logic* and *functional relationships* iii) In such a context, the M. Em-P. Principle is able to give a very general perspective to the Problem, but it is not able, by itself, to completely solve the problem analyzed	This approach, vice versa, appears as being valid: i) *in any field* of analysis (from *non-living* Systems, to *living* Systems and also *human social* Systems (e.g. Economics)); ii) *at any scale* of analysis (from atoms to Galaxies); iii) *under steady state and dynamic conditions*; iv) and, in particular, without *any reference* to specific Physical Laws or the well-known Thermodynamic Principles; v) The *uniqueness* of the approach has also a clear reflex in the fact that the same "EQS" can be adopted for all the problems to be analyzed

In spite of such profound differences, it is worth pointing out that the two approaches are always "com-possible", both at logical and practical levels.

ii) "Com-possibility" of Approaches

The two approaches here considered, although based on TDC and IDC, respectively, *do not exclude each other*. Their "Com-possibility" can clearly be asserted on the basis of their pertaining presuppositions synthetically recalled in Table 3 (see also Giannantoni 2012).

In fact, the former *is not able to exclude* (in principle) the "Generative" Approach, because it is based on the hypothetical-deductive method (see Tab. 3) which, in turn, is intrinsically based on logical "necessity".

Consequently, because of the *absence* of any form of *perfect induction* in "necessary" logic (which would transform, only in this case, the first approach in an *absolute* perspective) it is impossible to assert the *uniqueness* of the *inverse* process. That is: it is impossible to show that the hypotheses adopted are the *sole* hypotheses that are able to explain the considered experimental results. In other terms, in *necessary logic* there always exists, in principle, an *infinity* of other *possible* hypotheses capable of leading to the same conclusions.

At the same time, the Generative Approach here proposed and, in particular, the hypothesis of "One Sole Reference Principle", does not "exclude", *in any case*, the previous one.

Firstly, because it is not interested in showing that the traditional approach is "false" (in the Popperian sense), because it simply recognizes that the traditional approach already has its own *internal* specific falsification criteria. On the contrary, it is much more interested in showing that Physical Processes cannot faithfully be described as mere "mechanisms", because of the ever-present Quality in all Processes, even if Quality manifests itself in different forms and modalities (Giannantoni 2002).

Secondly, because the traditional approach maintains its validity for physical processes described by low order differential systems and/or time intervals comparable with the dominating time constants of the process analyzed.

Thirdly, and in particular, because the "Generative" Approach proposes an *Ordinal* Perspective which may lead us to more appropriate solutions, especially where (and when) the

former fails. (Think of, for example, the "Emerging Solutions" in the case of "Unsolvable" Problems, "Intractable" Problems and "Drift" Problems).

In essence, the "Generative" Approach would only shows that: "*We can do better*". Obviously, by *always* sustaining such an assertion on the basis of *experimental results*.

Table 2 - Synoptic Comparison between the Basic Presuppositions pertaining to TDC and IDC

Traditional Differential Calculus	*Incipient* Differential Calculus
1) efficient causality 2) necessary logic 3) functional relationships	1') Generative Causality 2') Adherent Logic 3') Ordinal Relations

d/dt is the corresponding formal translation	$\tilde{d}/\tilde{d}t$ is the corresponding formal translation
$f(t)$ represents a *functional relationship*	$\tilde{f}(t)$ represents an *Ordinal Relationship*

Traditional approach *cannot exclude* the other, because of the *absence* of any form of *perfect induction* in the hypothetical-deductive method: Structure of hypothetical-deductive method **Hypotheses** ↓ **Mathematical Formalization** ↓ **Conclusions** ↓ **Confirmation by experimental results**	The new Approach *does not "exclude"* the former, *in any case*: **i) because also in this case there is no form of *perfect induction*** **ii) consequently, this approach may only indicate that the traditional perspective is generally valid in the case of physical processes described by differential equations (or systems of differential equations) of very low order and/or time intervals comparable with time constants of the process analyzed**

iii) Radical Differences in Thinking, Decision Making and Acting

The different presuppositions just recalled, together with the Ostensive Examples previously shown, concerning "Unsolvable" Problems, "Intractable" Problems and "Drift" Problems, suggest:

i) We Think in Generative terms when analyzing a given Natural System or designing any new artificial System. This more explicitly means to research for the intrinsic Quality of the Process, which manifests itself in an Ordinal Generativity that can be modeled in terms of Ordinal "Incipient" Derivatives. This is because such a Formal Language is able to show whether the System tends (or not) to the Maximum Ordinality;

ii) We Make Decisions in the respect of those Solutions which are "Emerging" from the mathematical model, in such a way as to take the maximum advantage from those corresponding "Emerging Exits" which are foreseen to be arising from the physical behavior of the System;

iii) We adopt, in actual fact, consequential Actions for favoring that specific "emerging behavior" of the System which appears as being decisively capable to improve our design.

This means conceiving and designing any System in such a way as it might work at is Maximum Intrinsic Stability conditions, so as to prevent not only any possible external disturbance that might significantly alter its expected behavior, but also (as we will show later on), some possible "side effects" associated to a (more or less marked) "distance" from those conditions.

In other terms, the adoption of the M. O. P., understood as "One Sole Reference Principle" (with its associated "Emerging Solutions") enables *any* Decision Maker, in *any field* considered, i) to recognize in advance those (theoretical) optimal working conditions which realize the Maximum Ordinality of the System under consideration and, at the same time, ii) to favor the corresponding "emerging behavior" (as an "Emerging Exit"), which is decisively capable to improve the internal Ordinal Stability of the System with respect to any possible, both *internal* or *external*, transient condition.

CONCLUSIONS

By taking into consideration that: i) the two approaches, in spite of their "com-possibility", are evidently not "equivalent"; ii) nonetheless the "option" in favor of one (or the other) between the two always remains substantially "free"; iii) the conclusions might be synthetically summarized by simply pointing out the *conceptual* and (consequently) *practical* differences between "side effects" (characteristic of the former approach) and the so-called "Emerging Exits" (which are strictly specific of the latter).

This is because the "consequences" corresponding to the two different *conceptual* "options" are always conform to their pertinent presuppositions.

In the first case, in fact, the analysis tends to focus on a well-defined and circumscribed aspect. The concept of "precision" in fact, does not simply mean "accuracy" of measurements. Its etymological meaning reveals, on the contrary, a more profound decision: that of realizing a "previous cut" (from Latin "pre-cision") in the System analyzed, in order to "isolate" *only* the aspect of interest. By loosing (and, at the same time, by denying), in this way, the relationships of that aspect to the entire System, which, on the contrary, should always be understood as a Whole.

In the second case, on the contrary, the Holistic Perspective adopted, based on the concept of Ordinal Generativity, starts from that renewed gnosiological approach introduced by Prof. Odum, who *first* accounted for the "Excess" of Quality of the three basic Generative Processes (Co-Production, Inter-Action, Feed-Back), by means the introduction of an original non-conservative Algebra. This is precisely the novelty that suggested we adopt a different mathematical language that progressively "guided" us to the Generative Approach and, in the end, to the formulation of the Maximum Ordinality Principle.

Consequently:

i) In the first Approach we always have the risk of a more (or less) marked "Drift" (apart from "Unsolvable" and "Intractable" Problems). This does not only means that there is a "distance" between foreseen and expected results. It also means, in addition, that such a "distance" is basically due to that "previous cut", operated in advance, when analyzing the considered System. In this respect, by adopting a term particularly used in Medicine and Pharmacology, we may say that such a "drift" reveals the ever-present risk of "side effects";

ii) In the Generative Approach, vice versa, the description of any System is always seen as the exit of a Generativity, characterized by a specific Ordinality. Such a description always leads to "Emerging Solutions", which reflect the "Excess of Quality" associated to the System. The latter in fact is always considered as a Whole from the same formulation of its mathematical model.

Such "Emerging Solutions", however, can also be termed as *not less than*, because the System analyzed, although considered as a Whole, is always "limited". This means that we have to expect some associated "Emerging Exits" (see Giannantoni 2012), which manifest an Extra-Quality that, nonetheless, is always in "consonance" with the "Emerging Solutions" obtained.

In extreme synthesis, the "option" between the two approaches can substantially be based on their characteristics, synthetically summarized in Tab. 3.

Table 3 - Synoptic Comparison between "side effects" and "Emerging Exits"

The Approach (d/dt)	The Approach $(\tilde{d}/\tilde{d}t)$
i) In this Approach (apart from "Unsolvable" and "Intractable" Problems), the presence of "drifts" is always a symptom of possible "side effects" ii) This is precisely because the concept of "*precision*" (as a "previous cut") and the consequential adoption of a "*functional*" *description*, *efficient causality* and *necessary logic*, prevents from knowing, in advance, the "effects" due to the remaining part of the System, as well as those due to the other Systems that constitute its surrounding habitat	i) In this case, vice versa, apart from the clear advantages of adopting "One Sole Principle" ii) the "Emerging Solutions" always suggest the presence of "Emerging Exits", directly referable to the those parts of the surrounding Systems not included in the preliminary description of the same iii) Such "Emerging Exits" can generally be recognized as being "Extra Ordinal Benefits", because these are always in "*consonance*" with the adopted approach based on Quality, properly understood as an "Irreducible Excess"

For the sake of completeness, we may also add that there exists an additional "Third" Option: that of adopting, contemporaneously, both the considered Approaches. This is simply because, as previously shown, they are always "Com-possible". In this way, after having analyzed the same System on the basis of both Approaches, it should be easier to make a decisive option (between the two), by recognizing the profound difference between "side effects" and "Emerging Exits", respectively.

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APPENDIX 1. THE CONCEPT OF EMERGING SOLUTIONS

The simplest way of presenting "Emerging Solutions" is that of making a comparison with traditional solutions, as synoptically shown in Table 4. Nonetheless, from a conceptual point of view, Emerging Solutions can be termed as such precisely because *they always show an Ordinal Information content which is much higher than the corresponding content of the initial formulation of the Problem*.

Table 4 - Traditional Solutions vs "Emerging Solutions"

Traditional Solutions (TS)	**"Emerging Solutions" (ES)**
1) TS are those solutions which originate from any traditional algebraic or differential problem	1') ES are those Solutions which emerge from any Ordinal Differential Problem formulated in terms of "incipient" derivatives
2) Consequently, they are solutions to all those mathematical models which describe each given system in terms of its pertaining traditional physical Laws	2') More specifically, they are those Solutions which describe any given System according to an Ordinal Model which is always based on the Maximum Ordinality Principle (M.O.P.)
3) TS are always represented by a formal expression that, when reintroduced into the initial formulation of the problem, reduces the latter to a perfect identity	3') ES progressively acquire their increasing Ordinality during the same solution process, so that, if reintroduced into the initial formulation of the Problem, the latter *does not reduce* to a perfect identity
4) They are "solution" to a problem in the sense of "loosing a *knot* "	4') They are "solution" to an Ordinal Problem in the sense of "disclosing *a seed* "

As an Ostensive Example of "Emerging Solutions" we could think of the "Three-body Problem". In fact, if the formal Solution to this problem, obtained in terms of the M.O.P., is re-introduced into the initial formulation of the same, we get the formulation of a new Ordinal Problem, corresponding to a "Six-body Problem" (and so on). This is because the "Inter-action

between the higher Ordinal information content of the Solution and the lower information content of the initial Problem give rise to a sort of a Feed-Back of Ordinal Nature, which can evidently be seen as a generalized version of the well-known Feed-Back in Emergy Algebra. This is precisely because the concept of “Emerging Solutions” traces back to the same Rules of Emergy Algebra.