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The "Emerging Quality" of Self-Organizing Systems, when modeled according to the Maximum Ordinality Principle, offers a Radically New Perspective to Modern Science

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ABSTRACT

Self-Organizing Systems and their "emerging properties" began to be studied by L. Boltzmann toward the end of XIX century. Several other Authors (e.g. A. Lotka) dealt with such a theme. However, Self-Organizing Systems received the most significant contribution by H.T. Odum (from 1955 on), with the genial introduction of a more appropriate formal language.

The consequential faithful developments of Odum's approach have led us to the formulation of a unique general Principle, the Maximum Ordinality Principle (M.O.P.), which is able to describe, by itself, the behavior of any given System as a Self-Organizing System: both "non-living" Systems, "living" Systems and "thinking" Systems too (e.g. Human Systems).

Such a conclusion then results as being deeply different from that of Modern Science, which, from Newton on, is persistently orientated at describing any known system as it were a "mechanism".

The present paper, after having synthetically recalled the fundamental steps that led us to the formulation of the M.O.P. and after having pointed out its corresponding descriptive advantages, will focus on the intrinsic new perspective offered by the M.O.P. especially in thinking, decision making and acting. *In particular, with reference to any form of relationship between Man and his surrounding environment.*

In this respect, the basic differences between the two afore-mentioned perspectives will be brought out by comparing, on the one hand, "side effects" (related to the traditional approach) and, on the other hand, "Emerging Exits" (specifically pertaining to the new approach).

INTRODUCTION

This paper represents a further development and, at the same time, a "relaunch" of the paper presented at the 8th Emergy Conference. In fact, on the basis of the Maximum Ordinality Principle (M.O.P.), understood as "One Sole Reference Principle" (Giannantoni 2014), we can now propose a radically new perspective in Modern Science, that is: "*Every System is a Self-Organizing System*".

To this purpose, in order to give a clear presentation of the fundamental differences with respect to the Traditional Scientific Approach, it is worth starting from the consideration of a synoptic picture of the basic characteristics of the two mentioned approaches (see Tab. 1), which will be analyzed and compared, in more detail, in the context of the paper.

FUNDAMENTAL CHARACTERISTICS OF THE TWO APPROACHES

Let us first consider the Traditional Approach that characterizes Modern Science.

Basic Presuppositions	***"Emerging Quality"* of Self-Organizing Systems**
1) causality principle (efficient causality) 2) classical logic (necessary logic) 3) functional relationships	1') Generative Causality 2') Adherent Logic 3') Ordinal Relationships

	Development of an appropriate Language
d / dt is the corresponding formal translation $f(t)$ represents a *functional relationship*	- L. Boltzmann, A. Lotka - H. T. Odum: Emergy Algebra and M. Em-P. P. - Further developments in transient conditions - Introduction of the "Incipient" derivative $\tilde{d} / \tilde{d} t$

- **Thermodynamic Principles (1st , 2nd, 3rd)** - **Physical Laws (specific for each Discipline)** **Every System is a "Mechanism"** **Hypotheses** ↓ **Mathematical Formalization** ↓ **Conclusions** ↓ **Confirmation by experimental results**	**The Maximum Ordinality Principle** - **is applicable to *any* Field of analysis: *non-living* Systems, *living* Systems, "*thinking*" Systems (e.g. Human Systems)** - **at *any space-time scale* and in *variable conditions*** - **it also offers a *more appropriate* description of any given System and its surrounding habitat** **Every System is a "Self-Organizing System"**

Tab. 1 - Synoptic comparison between the fundamental characteristics of the two Approaches

The Traditional Scientific Approach

Modern Science is characterized by a persistent and progressively ascendancy toward ever more general Physical Laws and Principles.

However, before any formulation of a single hypothesis or a physical theory, Modern Science (let us say, from Newton on) adopts three fundamental *pre-suppositions* (see Tab. 1): the *causality principle* (also termed as "efficient causality"), *classical logic* (also termed as "necessary logic"), and *functional relationships* (between the various parts of any System analyzed).

On the basis of such fundamental presuppositions, and only after having developed a strictly conform consequential *formal language* (that is Traditional Differential Calculus (TDC)), Modern Science progressively ascends toward ever more general Physical Laws and Principles:

i) from Phenomenological Laws (e.g. Kepler's Laws); ii) to Physical Laws specific of each Discipline (e.g. Newton's Laws, Maxwell's Equations, etc.); iii) up to the three well-known Thermodynamic Principles.

Such a progressive development has given origin to a hierarchy of a multiplicity of *quantitative* Physical Laws and Principles, in particular as a consequence of the first basic presupposition: the *causality principle*. This Principle, in fact, has led Modern Science to introduce "different causes" in different Disciplines. The Principle of causality, in fact, tends to "sub-divide" the entire phenomenology (at present known) in different "branches", precisely because, on the basis of such a presupposition, it leads Scientists to research for the most "appropriate causes" pertaining each specific set of phenomena each time considered.

In this way, Modern Science persistently propends to show that: "*Every System is a mechanism*".

Such a conclusion, however, although confirmed by experimental results, can be considered as being valid *only* from an *operative* point of view, but not from an *absolute point of*

view. This is because "necessary logic" (adopted as a second basic presupposition) does not admit any form of "*perfect induction*".

In fact, as synthetically illustrated in Tab. 1, in the strict contest of "necessary logic":

i) after having formulated a single or more hypotheses (such as in the case of a Theory);
ii) after having formalized them in an appropriate formal language (faithfully conform to the three above-mentioned basic presuppositions);
iii) after having drawn the consequential conclusions
iv) and after having also obtained experimental confirmations of the previous formal conclusions;
v) it is impossible, *in any case whatsoever*, to assert the *uniqueness* of the *inverse* process. That is: it is impossible to show that the hypotheses adopted are the *sole* and *unique* hypotheses capable to explain those experimental results.

This is precisely because of the *absence*, in "*necessary*" logic, of any form of *perfect induction*. In fact, only in the presence of a *perfect induction* it would be possible to assure the *uniqueness* of the *inverse* process and, thus, to transform the adopted hypotheses into an *absolute* perspective.

This means that Modern Science, precisely because based on *necessary logic*, should always be "open" to recognize that *there always exist* many other *possible* Approaches (in principle *infinitive*) capable to interpret the same experimental results.

At this stage, after having synthetically recalled the basic characteristics of Modern Science, we can analyze in more detail the fundamental properties of the New Perspective, synthetically indicated in parallel (for a better comparison) in the right hand side of Tab. 1.

"Emerging Quality" of Self-Organizing Systems and Consequential Adoption of New Mental Categories

The expression "*Emerging Quality of Self-Organizing Systems*" refers to the fact that Self-Organizing Systems always show an unexpected "*excess*" with respect to their phenomenological premises. So that they usually say: "*The Whole is much more than its parts*".

Such an "excess" can be termed as *Quality* (with a capital Q) because it cannot be understood as being a simple "property" of a given phenomenon. This is because it is *never reducible* to its phenomenological premises in terms of traditional mental categories: *efficient causality*, *logical necessity*, *functional relationships*.

This evidently suggests a *radically new* gnosiological perspective, which corresponds to recognize that: "*There are processes, in Nature, which cannot be considered as being pure* "*mechanisms*".

This also leads, *in adherence*, to the adoption of "*new mental categories*"[1] and, correspondently, to the development of a completely *new formal language*, so that the description of Self-Organizing Systems might result as being faithfully conform to their "Emerging Quality".

The Progressive Development of an Appropriate Formal Language

L. Boltzmann was the first who attempted at describing Self-Organizing Systems in more appropriate formal terms, by proposing the adoption of a new Thermodynamic Principle: The Principle of Maximum Exergy *Inflow* to the System (Boltzmann 1886).

Some years later, A. Lotka (1922-1945) reformulated such a Principle in the form of: The Principle of Maximum Exergy *Flow through* the System (Lotka, 1922a,b, 1945).

Both such attempts were not perfectly successful, because still based on the concept of Exergy, which is a quantity that is strictly pertaining to Classical Thermodynamics. Consequently, it re-proposes the concepts of *efficient causality*, *logical necessity*, *functional relationships*.

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[1] These "*new mental categories*" can no longer be termed as "pre-suppositions", because they are not defined "a priori" (as in the case of Traditional Approach). In fact, they are chosen only "a posteriori", on the basis of the "Emerging Quality" previously recognized. "*Generative Causality*", in fact, refers to the *capacity* of a Self-Organizing System to manifest an "irreducible excess"; "*Adherent Logic*", correspondently, refers to the capacity of our mind to draw "*emerging conclusions*". That is, "conclusions" whose information content is much higher than the information content corresponding to their logical premises, although persistently "adherent" to the latter. "Ordinal Relationships", in turn, refer to particular relationships of *genetic nature*, which will be illustrated in more details later on, in the case of a Co-Production Process.

A really *new formal language* only appears with H. T. Odum, with the genial introduction of Emergy (*Em*), defined as Exergy (*Ex*) by Transformity (*Tr*)

$$Em = Ex \cdot Tr \qquad (1).$$

Equation (1) clearly shows that Emergy is *still* based on "Exergy". However:
i) *Quality Factor Tr* "*Transforms*" *Ex* into a *new physical quantity*: Emergy;
ii) The latter in fact is not defined in "functional terms", but only by "*assignation Rules*" (Brown and Herendeen, 1996);
iii) This is precisely because *Tr* is expressed by means of a *non-conservative Algebra*;
iv) Thus the output "excess" of the three Fundamental Process (Co-Production, Inter-Action, Feed-Back) is always understood as being "irreducible" to its specific inputs in *mere functional terms*.

This means that Emergy is able to represent the "Emerging Quality" of Self-Organizing *Processes*. Consequently, the general enunciation of the *Maximum Em-Power Principle* (Odum 1994a,b,c) can *equally be referred*, at a phenomenological level, to the *corresponding maximization tendency* of the "Emerging Quality" on behalf of *Self-Organizing Systems*.

The Maximum Em-Power Principle, however, had not a corresponding formulation under *variable conditions*. On the other hand, such a formulation could not be given in terms of the Traditional Differential Calculus, because traditional derivatives, as a consequence of their conceptual basic presuppositions (see Tab. 1), are not properly apt to represent the "generative" behavior of "Self-Organizing Systems".

This is why, in order to achieve an appropriate mathematical formulation of the Maximum Em-Power Principle, I introduced the concept of "*Incipient Derivative*", defined as

$$\left(\frac{\tilde{d}}{\tilde{d}t}\right)^{\tilde{q}} f(t) = \underset{\tilde{\Delta}t:0\to 0^{+}}{\tilde{Lim}} \circ \left(\frac{\tilde{\delta}-1}{\tilde{\Delta}t}\right)^{\tilde{q}} \circ f(t) \qquad \text{for} \quad \tilde{q} = \tilde{m}/\tilde{n} \qquad (2).$$

A definition which clearly shows that the "*Incipient Derivative*" is not an "operator", like the traditional derivative (d/dt), but it could be termed as a "*generator*", because it describes a Process in its same act of being born (Giannantoni 2001a,b, 2002, 2004a,b, 2006, 2008a, 2010a).

The Mathematical Formulation of the M. Em-P. Principle in terms of *Incipient Derivatives* was preliminarily given in (Giannantoni 2001b) and, in a more articulated form, in a specific book co-financed by the Center for Environmental Policy (Giannantoni 2002).

During the successive eight years (2002-2010), such a mathematical formulation was applied to several Disciplines, such as *Classical Mechanics*, *Quantum Mechanics*, *General Relativity*, *Chemistry*, *Biology*, *Economics and the corresponding results were reunited in two books* (titled: *"Lightness of Quality"* (Giannantoni 2007) *and "Ascendency of Quality*" (Giannantoni 2008b).

At the end of this wide range of applications, I realized that it was possible to give a more general formulation of the Maximum Em-Power Principle, in the form of the "*Maximum Ordinality Principle*" (Giannantoni 2010a). For the sake of clearness, the Rational of such a generalization process, articulated in a few logical steps, is recalled in the next section.

FROM THE MAXIMUM EM-POWER PRINCIPLE TO THE MAXIMUM ORDINALIY PRINCIPLE

Such a generalization process, already presented in several previous papers (Giannantoni 2010a, 2012, 2014), is here re-proposed, in an extremely synthetic way, so as to clearly show that The M. O. P. is nothing but the *reformulation* of the Maximum Em-Power Principle.
The Rational of such a generalization process essentially consists in two conceptual steps:

i) *the transformation* of the three fundamental processes introduced by Odum (which are generally valid under steady-state conditions) into three Generative Processes, by means of the afore-mentioned "incipient" derivative, whose mathematical definition (2) represents the faithful reflex of the three new mental categories shown in Tab. 1;

ii) *the subsequent formulation* of the M.O.P., referable to any given System, by means of *one sole* "incipient" derivative, characterized by a proper Ordinality, which is each time specific of the System under consideration**.**

To this purpose, let us first consider a *Co-Production* and an *Inter-Action* Process under *variable conditions*:

a) A **Co-Production Process** can be modeled by means an incipient derivative of Ordinality $1/\tilde{2}$. Its output is then represented as a "Binary" Ordinal Relationship (see Fig. 1),

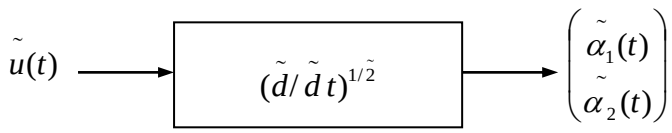


Fig. 1 - Representation of a Co-Production as a Generative Process

in which the two generated entities, $\tilde{\alpha}_1(t)$ and $\tilde{\alpha}_2(t)$, are equal to each other, not as consequence of a logical or physical "necessity", but only because they are related through an "Ordinal" Relationship; that is, a Relationship that originates from *the same Generative Process*. Consequently, they are equal to each other only for "assignation", a concept that can formally be represented as follows

$$\tilde{\alpha}_1(t) \overset{*}{=} \tilde{\alpha}_2(t) \qquad (3).$$

In fact they are related to each other according to the same "Ordinal" Relationships that take origin from the *genesis of two tweens* (or, more in general, *two brothers*).

Two *tweens* (or "*brothers*"**)**, in fact, are properly termed as such, not because of their *direct* relationships. That is: because they respect each other or they love each (in fact, they might also hate each other). They are "brothers", *in essence*, because generated by the same father (or the same mother, or both). That is, because of their *direct Relationship* with the *same generative cause* of their being born. Such a *genetic* Relationship, in fact, represents something that is *unique*, *specific* and *irreducible*. Consequently, they cannot simply be accounted for as "two" (1+1), but as *one sole entity*. That is, as a *Whole*, a concept explicitly represented by the symbol $(\ )$ in Fig. 1.

This brings out that the Relationship between "*brothers*" refers to a clear "*irreducible extra*": precisely that represented by *their specific Relationship* with the *same and unique genetic Principle*.

b) Analogous considerations can be extended to an **Inter-Action Process**.

This Process, in fact, can be modeled by means of an incipient derivative of Ordinality $\tilde{2}$. Its corresponding output is then represented as a "Duet" Ordinal Relationship (see Fig. 2),

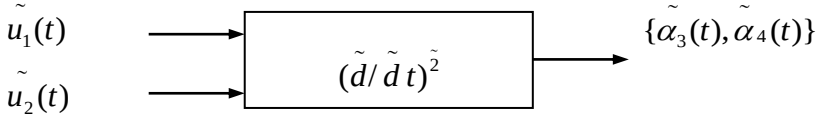


Fig. 2 - Representation of an Inter-Action as a Generative Process

in which the two generated entities, $\tilde{\alpha}_3(t)$ and $\tilde{\alpha}_4(t)$, are, once again, equal to each other only by "assignation", for the same reasons previously illustrated. The Process then represents a form of *Co-operation* of Ordinal Nature (think, for example, of a "Duet singing").

c) Co-presence of a Co-Production and an Inter-Action Process. In this case the Whole process can be modeled by an incipient derivative of Ordinality $\tilde{2}/\tilde{2}$. Its corresponding output is then represented as a "*Binary-Duet*" Ordinal Relationship (see Fig. 3),

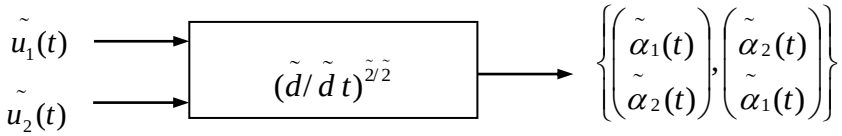


Fig. 3 - Co-presence of a Co-Production and an Inter-Action Process

which can be interpreted as: the Generation of two "Brothers" collaborating with each other.
This latter case represents the best way of understanding the successive passage to the mathematical formulation of the Maximum Ordinality Principle.

The Mathematical Formulation of the Maximum Ordinality Principle

The mathematical formal enunciation of the M.O.P., in fact, can be expressed as follows (see Giannantoni 2010a):

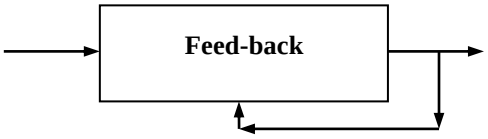
$$(\tilde{d}/\tilde{d}\,t)^{(\tilde{m}/\tilde{n})}\{\tilde{r}\}_s = 0 \quad (4) \qquad (\tilde{m}/\tilde{n}) \rightarrow Max \rightarrow \{\tilde{2}/\tilde{2}\} \uparrow \{\tilde{N}/\tilde{N}\} \quad (4.1)$$

where: $(\tilde{d}/\tilde{d}\,t)$ is the symbol of the incipient derivative; $\{\tilde{r}\}_s$ is the proper Space of the System; $(\tilde{m}/\tilde{n})$ is the Ordinality of the System under consideration, that reaches its *maximum* when it equals $\{\tilde{2}/\tilde{2}\} \uparrow \{\tilde{N}/\tilde{N}\}$ (as indicated in Eq. (4.1)).
Under such conditions, the explicit Solution to Eq. (4) is structured in the following form

$$\{\tilde{r}\} = e^{\{\tilde{\alpha}(t)\}^{(\tilde{N},\tilde{N})}} = e^{\left\{\begin{pmatrix}\tilde{\alpha}_{11}(t)\\ \tilde{\alpha}_{21}(t)\\ \cdots\cdots\\ \tilde{\alpha}_{N1}(t)\end{pmatrix},\begin{pmatrix}\tilde{\alpha}_{12}(t)\\ \tilde{\alpha}_{22}(t)\\ \cdots\cdots\\ \tilde{\alpha}_{N2}(t)\end{pmatrix}\begin{pmatrix}\cdots\cdots\\ \cdots\cdots\\ \cdots\cdots\\ \cdots\cdots\end{pmatrix}\begin{pmatrix}\tilde{\alpha}_{1N}(t)\\ \tilde{\alpha}_{2N}(t)\\ \cdots\cdots\\ \tilde{\alpha}_{NN}(t)\end{pmatrix}\right\}} \quad (4.2)$$

which exactly represents the Structural Organization of the System as generated by a joint *cooperation* of *N Co-Productions* and *N Inter-Actions*, all understood as Generative Processes. This is because:

i) each term $\tilde{\alpha}_{ij}(t)$ of the Ordinal Matrix in Eq. (4.2) represents a couple of elements that originates from a Generative Process of Ordinality $\{\tilde{2}/\tilde{2}\}$, that is as a joint cooperation between a Co-Production and an Inter-Action Process, both of Generative Nature (see Fig. 3);
ii) at the same time, each "column" of the same Ordinal Matrix represents the extension of the concept of a "Binary" Relationship (see Fig. 1) to *N* elements. Each "column", in fact, represents the "emerging" output of a Generative Co-Production Process of Ordinality $1/\tilde{N}$;
iii) while the *N* columns of the same Ordinal Matrix, considered all together as one sole entity, represent the "emerging" output of a Generative Inter-Action Process of Ordinality $\tilde{N}$;
iv) the System Generation Process, however, becomes complete when, in addition, the System is considered as being generated by a *global* Feed-Back Process of Ordinal Nature (see Fig.4).
Its associated formal output, in fact, represented by Eq. (5), formally asserts that the *proper Space*



$$(\tilde{d}/\tilde{d}\,t)^{(\tilde{2}/\tilde{2})}\{\{\tilde{r}\} \otimes (\tilde{d}/\tilde{d}\,t)^{(\tilde{2}/\tilde{2})}\{\tilde{r}\}\} = 0 \quad (5).$$

Fig. 4 – Feed-Back between the System and its specific Generativity

$\{\tilde{r}\}$ of the System is coupled with its specific Generativity, so as to originate a *comprehensive* Generative Capacity which, *at any time*, is always *in equilibrium* (including its initial conditions).[2]

As a consequence of this "global" Feed-Back Process, all the elements $\tilde{\alpha}_{ii}(t)$ are equal to zero, whereas all the other elements $\tilde{\alpha}_{ij}(t)$ satisfy the following Relationships

$$\{\tilde{\alpha}_{ij}(t)\}^{\{\{\tilde{2}/\tilde{2}\}\uparrow\{\tilde{2}\uparrow\}\}} \overset{*}{=} \{\tilde{\alpha}_{ji}(t)\}^{\{\{\tilde{2}/\tilde{2}\}\uparrow\{\tilde{2}\uparrow\}\}} \quad (6),$$

which represent an *intensive form of Ordinal Symmetry*, characterized by the *absence* of any form of *internal priority* in any couple considered. A concept which is much more profound than the traditional concept of symmetry (this is why the adoption of the symbol "$\overset{*}{=}$", which indicates an assignation condition).

These properties are the basis of the *real novelty* of the M.O.P., which resides in its *Solutions*. The latter, in fact, not only are *always explicit* but, for their particular structure (see Eq. 7)), they can also be termed as *Harmony Relationships*:

$$\{\tilde{\alpha}_{1,j+1}(t) \oplus \tilde{\lambda}_{1,j+1}\} \overset{*}{=} (\sqrt[N-1]{\{\tilde{1}\}})_j \,®\, \{\tilde{\alpha}_{12}(t) \oplus \tilde{\lambda}_{12}\} \quad \text{for } j = 1,2,3,\ldots N-1 \quad (7).$$

This is because: i) all couples $\tilde{\alpha}_{1,j+1}(t)$ can be obtained by assuming one *sole* reference couple $\tilde{\alpha}_{12}(t)$, together with *N-1* Correlating Factors $\tilde{\lambda}_{1,j+1}$ (related to the *initial* conditions);

ii) whereas the *N-1* Ordinal Roots $(\sqrt[N-1]{\{\tilde{1}\}})_j$ of Unity $\{\tilde{1}\}$ (whose specific sequence depends on the reference couple adopted) transform *Explicit Solution* (7) into an "*Emerging Solution* ". That is, a Solution "whose *information content* is *much higher* than the information content corresponding to the initial formulation of the problem" (Giannantoni 2012).

This is precisely the reason why the Maximum Ordinality Principle is *potentially able* to describe the "*Emerging Quality*" of "Self-Organizing Systems".

THE M.O.P. AS "*ONE SOLE REFERENCE PRINCIPLE*" FOR "SELF-ORGANIZING SYSTEMS"

In this section we will consider some problems that, according to the Traditional Approach, are *classified* as being "unsolvable", "intractable" or characterized by an output "drift". These problems, although already dealt with in previous papers, will be now reconsidered to clearly show that they precisely result as such simply because the Traditional Approach usually describes them in mere "functional terms", that is, as simple "mechanisms", whereas they are "Self-Organizing Systems", and thus characterized by an "*Irreducible Excess*".
For the sake of clearness, the above-mentioned problems will be articulated in the three new "classes": "*non-living*" Systems, "*living*" Systems, and "*thinking*" Systems (e.g. human Systems).

"Non-living" Systems:

i) The "**Three-Body Problem**", demonstrated as being unsolvable by H. Poincaré (in 1889), was explicitly solved in the light of the M.O.P. (Giannantoni and Rossi, 2014) and then directly applied, for the sake of generality, to the entire Solar System.
With reference to this problem, it is worth noting that the same Poincaré pointed out that the adoption of a *functional* approach, typical of Classical Mechanics, prevented him from getting an explicit solution. This is precisely because "*The conservation of Energy is a limitation imposed on*

[2] The symbol $\otimes$ represents a generalized form of the "vector" product between *spinors* (Giannantoni 2010a).

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 Mirowski, 2000, p. 5).
Such a concept becomes even clearer if we consider another *associated* problem:

ii) The distribution of the Planets in the Solar System

Such a distribution is approximately described by semi-empirical Bode's Law, which, however, has never found a physical foundation, neither in Classical Mechanics nor in General Relativity. This essentially depends on the fact that both these Theories (as already anticipated) intrinsically tends to research for a solution in mere *functional* terms.

If, on the contrary, the Solar System is modeled as a Self-Organizing System, the Solution to the Problem can easily be obtained on the basis of the M.O.P..
The corresponding Harmony Relationships, in fact, can be expressed as follows

$$\{\tilde{\rho}_{1,l+1}, \tilde{\varphi}_{1,l+1}, \tilde{\vartheta}_{1,l+1}\}_t \overset{*}{=} (\sqrt[11-1]{\tilde{1}})_j \,\textcircled{R}\, \{\tilde{\rho}_{12}, \tilde{\varphi}_{12}, \tilde{\vartheta}_{12}\}_t \qquad (j = 1,2,.,11-1) \qquad (8).$$

So that, if for instance we assume that the couple "12" refers to Sun-Mercury, Eq. (8) gives, at *any time*, the distribution of the pertinent *distances*, *angular anomalies* and *angles of orbital planes*.

Equation (8), in fact, is an "Emerging Solution" and, consequently, precisely because of its higher information content, is able to describe the "Emerging Quality" of the Solar System, when understood as a "Self-Organizing System".
This is also the proper reason why the distribution of the Planets, although researched for by Classical Mechanics and General Relativity, cannot be obtained in mere "functional terms", whereas the same problem implicitly solves another *associated* problem of Classical Mechanics:

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

This represents another case in which there is no satisfactory explanation, in Classical Mechanics, of the above-mentioned 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 of the orbital planes, in fact, are distributed in a cone of a rather large width (20°), which reduces to 10° only if the extreme Planets (Neptune and Pluto) are "excluded" (because the latter are usually considered as being rather "anomalous").
The problem also depends on the fact that the Traditional Approach tends to "separate" the various phenomenological aspects, without seeing the Solar System as a Whole.

In fact, the corresponding "Emerging Solution" to this problem is already given by the same Eq. (2), that is, it is given *contextually* with the "Emerging Solutions" pertaining to both the *distances* of the various Planets and the correlative *angular anomalies*.

As an immediate consequence, we could also say that Eq. (2) represents a sort of *one sole* and *unique* "Inflorescence" of "Emerging Solutions", describing the Solar System as a "Self-Organizing System".

iv) Precessions of the Planets

Equation (2) is also able to show an additional "Irreducible Excess" concerning the Solar System: the Precessions of the Planets. General Relativity, in fact, assumes that their values are always "constant" in time. In reality they result as being variable (in time), and their "*time variations*" are described by a *unique* evolutionary "Emerging Solution" of the M.O.P., when the latter describes the *time evolution* of the Solar System always as a "Self-Organizing System" (Giannantoni 2010).

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

The previous considerations developed with reference to the Solar System, can easily be extended to the angular velocities of the Stars in any given Galaxy.
In fact, the non-Keplerian distribution of velocities inside any Galaxy led Scientists to suppose the presence of a "non-visible" matter (thus termed as "dark") that could explain such an *unexpected behavior*. This is because the general tendency of the Traditional Approach (as previously said) is that of "reducing" any new "effect" to "functional causes".

Vice versa, if any given Galaxy is thought of as a "Self-Organizing System", and it is modeled on the basis of the M.O.P., it is rather easy to show that, apart from a very limited area near the center of the Galaxy, we always have that

$$\rho_{1j}(t) \cdot \overset{\circ}{\varphi}_{1j}(t) \cong \cos t \qquad (9),$$

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.

Equation (9) then shows that there is no "necessity" to introduce the hypothesis of "Dark Matter". The distribution of the stars in a Galaxy, in fact, manifests an "*Irreducible Excess*" that cannot be interpreted in terms of a common Keplerian trend, represented by

$$\rho_{1j}(t) \cdot \overset{\circ}{\varphi}_{1j}(t) \cong \cos t / \sqrt{\rho_{1j}(t)} \qquad (10).$$

The difference between Eq. (9) and Eq. (10), however, is able to explain the "subjacent" reasons that lead Scientists to formulate the hypothesis of "Dark Matter".

At the same time it is also able to show the wide "flexibility" of the M.O.P. in modelling the "Emerging Quality" of "Self-Organizing Systems" ranging from 11 bodies (Solar System), up to $50 \div 100 \cdot 10^9$ Stars of a Galaxy (see also Giannantoni 2014).

"Living" Systems:

i) Protein Folding is a fundamental problem in *Medicine* for understanding the origin of several important pathologies (Alzheimer, Parkinson, Mad Caw, etc.). However, it results as being maximally "intractable", especially when modeled at the level of single atoms. In fact, it requires a computation time of about 10.000 years even if run on the most updated computers (1 Petaflop). This is because, according to the Traditional Approach, Protein Folding is usually modeled as it were a "mechanism".

Vice versa, when Protein Folding is thought of as a "*Self-Organizing Process*", and it is modeled in the light of the M.O.P, it requires only some minutes, even in the case of macroscopic Proteins, such as Dystrophin, made up of about 100.000 atoms (Giannantoni 2010b, 2011a).

In this case, in fact, the corresponding "Emerging Solution" is precisely that which represents the "Emerging Quality" of the given Protein which, precisely because understood as a Whole, is characterized by an "Irreducible Extra" that can never be described as a mere "mechanism".

ii) Protein-Protein Interaction (PPI)

PPI decisively represents, in turn, a fundamental process in *Pharmacology*. However, in spite of its recognized importance, it has not manifested all its potentialities yet, mainly because of its intrinsic unsolvability in explicit terms, because of the famous "Three-body Problem".

Each Protein, in fact, is made up of amino acids, that interact among them according to Coulomb's forces. The latter, apart from their intensity, have the same structure as gravitational forces. Consequently, it sufficient to consider three amino acids to reproduce the "Three-body Problem" (H. Poincaré, 1889).

Vice versa, when PPI is thought of as a "Self-Organizing System" and, correspondingly, it is modeled according to the M.O.P., it always presents an *explicit solution* in the form of Harmony Relationships.

As an immediate consequence, the corresponding Ordinal Interaction Model can be run (through an appropriate Simulator) on a simple PC and requires a computation time of about 1-2 seconds.

These results have already been shown in (Giannantoni 2015), with reference to the case of Diabetic Therapy, in order to find the optimum interaction affinity between Insulin (made up of 51 amino acids) and blood Albumin (made up of 585 amino acids).

iii) Exon Skipping in Duchenne Muscular Dystrophy (DMD).

This Process represents an example of Ordinal Inter-Action between two distinct biological compounds, finalized to restore an efficient form of Dystrophin in children who suffer from such a severe pathology, as a consequence of a genetic *mis*-folded Dystrophin.

In analogy with PPI, the Interaction between the mis-folded Dystrophin and some appropriate AONs (Antisense Oligo-Nucleotides) is still modeled as a "*Self-Organizing System*". Such an assumption, when modeled on the basis of the M.O.P. and its related Harmony Relationships, is able to suggest a *unique and sole method* in order to restore all the 78 possible forms of *mis*-folded Dystrophin, instead of adopting 78 different "functional processes" (private communications with LUMC (Leiden University Medical Center));

"Thinking" Systems (e.g. Human Systems):

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

Neo-Classical Economics, which at present seems to represent the most followed Economic Theory in the world, is characterized, from its origin (at the beginning of the XX century) by an unsolvable problem: *The three-good two factor Problem*, which has never been solved up to now. This Problem consists in the fact that, given three goods, in a free market, characterized by two productive factors (*Kapital* and *Labour*), such three goods do not reach an equilibrium condition.

If vice versa the Market is considered as a "Self-Organizing System", in which any transaction generates "*Extra*" *Ordinal Benefits* (Giannantoni 2009), the Problem, when modeled in the light of the M.O.P., can be solved for an arbitrary number of goods (N_g), in the presence of *Three Productive Factors: Capital (K), Labour (L) and Natural Resources (N)* (Giannantoni 2011b). The corresponding "Emerging Solution" is given by the following Harmony Relationships

$$\{\tilde{K}_{1,j+1}, \tilde{L}_{1,j+1}, \tilde{N}_{1,j+1}\} = (\sqrt[N-1]{\{\tilde{1}\}})_j \, ® \{\tilde{K}_{12}, \tilde{L}_{12}, \tilde{N}_{12}\} \qquad j = 1,3,.....N_g - 1 \qquad (11),$$

where, as usual, the index "12" represents the couple of goods assumed as a reference.
The case of two sole productive factors can obviously be obtained by assuming $N = 0$.

ii) The "unexplained" sea level rise over the period 1900-2000

This example is particularly meaningful because it shows that the "separation" among different effects (as usually happens in the Traditional Approach) not always leads to the expected results.

Global sea level has been rising, in fact, 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 indicated a value of 3.2 mm/year (WMO, 2013). Nonetheless, theoretical estimations obtained by means of traditional methods give a foreseeable trend of 6.0 cm/century.

The interpretation of such a difference, preliminarily based on the sole adoption of IDC (Giannantoni and Zoli, 2009a), has led to a net increase of *not less than* 17.0 cm/century (ib.).

Such a result, however, when more appropriately analyzed in the light of the M.O.P., that is by considering the *co-operative* Ordinal Interactions between all the various physical Systems involved (sun, sea, ice, hearth, forests, etc.), may easily reveal that such an *"unexpected" trend* of the sea level rise is nothing but an "Emerging Solution" of *a unique* "*Self-Organizing System*".

iii) Transposition of the Models among Proper Spaces of Analysis

From a more general point of view, we can also consider the transpositions of the various models already analyzed into new different Spaces of Analysis, by adopting, of course, the appropriate corresponding *State variables*.

Such an extremely general modelling perspective, already illustrated in (Giannantoni 2012), is able to clearly show that the M. O. P. can be adopted as *one sole Reference Principle* for describing any sort of Systems (both "non-living" Systems, "living" Systems and "thinking" Systems too), always understood as "*Self-Organizing Systems*".

Such a general perspective enables us to assert that: "*Every System is a Self-Organizing System*".

In other terms**,** at the root of any "Self-Organizing System" there is always an "*Irreducible Quality*". That is, an *Intrinsic Self-Organization Capacity* which can be modeled, by means of the M.O.P, as a *Generativity* of *Ordinal Nature*. In fact, the same mathematical formulation the M.O.P. clearly shows that: "Every System can always be modeled by means of *one sole* "Incipient" Derivative, characterized by a specific "Ordinality", which is understood as the "*cipher*" of the *intrinsic Generativity* of the "*Self-Organizing System*" under consideration".

TWO COM-POSSIBLE APPROACHES, ALBEIT NOT "EQUIVALENT"

The two considered Approaches are *always possible*, or better, "*com-possible*". This is precisely because they *cannot exclude each other*. Consequently, they simply *co-exist*.

In fact, as already anticipated, the Traditional Approach *cannot exclude* (in principle) the "Generative" Approach because of the *absence*, in "necessary" logic, of any form of *perfect induction*. On the other hand, the same happens in the case of the Generative Approach, precisely for the *same reason*, although the latter is based on a different logic (the "adherent" logic).

Nonetheless, the two Approaches are not "equi-valent" between them.
The most evident aspect of such an *in-equivalence* is that: on the one hand, Traditional Approach is generally characterized by "*side effects*", whereas the Generative Approach generally presents "*Emerging Exits*" (which can always be understood as being "*Extra Benefits*").

"Side Effects" vs "Emerging Exits"

One of the most meaningful examples of "side effects" (vs "Emerging Exits") is represented by the Blackout of Smart Grids

In fact it is well-known that, when a Smart Grid reaches the number of about 100.000 plants (or more), it may present some forms of instability. The latter can always be described, in pure formal terms, as being associated to a distortion "drift" in their physical parameters (with respect to a perfect sinusoidal trend). Such a "drift" generally tends to amplify even under normal exercise conditions, because of the different currents produced by the *N* generators (Giannantoni 2012, Ecological Modelling 271 (2014) 62-71). However, when the instability leads to a blackout, the latter can more properly be seen as a form of "*side effect*". This is precisely because the Grid is conceived and designed as a "mechanism": the electrons are "forced" into the Grid according to Kirchhoff's laws, by means of N generators, which are distributed according to specific "functional exigencies".

In this way, however, the Smart Grid is designed without taking into account what was already pointed out by P. Anderson (Nobel Prize *in Physics*, 1977): "*A complex aggregate of electrons shows properties that are not reducible their sum*" (Anderson 1972). In other words, *a complex aggregate of electrons*, although "forced" by generators into electrical circuits, always tends to behave as a "*Self-Organizing System*".

This means that the distribution of the *N* Generators (and their related connections) should not be designed in mere functional terms. On the contrary, they should be distributed in such way as the Voltage ($\tilde{V}_i$), Current ($\tilde{I}_i$) and Phase ($\tilde{\Phi}_i$) of each generator satisfy, at any time *t*, the Harmony Relationships pertaining to the Smart Grid under consideration:

$$\{\tilde{V}_{1,j+1}, \tilde{I}_{1,j+1}, \tilde{\Phi}_{1,j+1}\}_t = (\sqrt[N-1]{\{\tilde{1}\}})_j \circledR \{\tilde{V}_{12}, \tilde{Y}_{12}, \tilde{\Phi}_{12}\}_t \qquad j = 1,3,.....N-1 \qquad (12)$$

where, as usual, the index "12" refers to the couple of generators assumed as reference.

Under such conditions, the Smart Grid not only presents an *intrinsic Ordinal Stability*, but also presents, as an "Emerging Exit" (or "Extra Benefit"), an *additional* Ordinal Stability with respect to *cyber attacks* too.

The Most Profound Reasons for the In-Equivalence Between the Two Compossible Approaches

The two Approaches in fact show their deepest difference: i) at the level of gnoseological perspective; ii) for their formal language (which represents the faithful reflex of the former); iii) and, above all, for their radically different ways of Thinking, Decision Making and Acting:

i) At the level of gnosiological perspective, the traditional Approach persistently tends to show that "every system is a *mechanism*", while the Generative Approach is always orientated at describing any system as a "*Self-Organizing System*";

ii) At the level of formal language, the traditional Approach is essentially based on TDC (Traditional Differential Calculus), which is the faithful reflex of the three basic presuppositions shown in Tab. 1. The Generative Approach, vice versa, is based on IDC (Incipient Differential Calculus), which translates, in formal terms, the three *new mental categories* (shown in the same Tab. 1), which are radically different from the three basic presuppositions of the former;

iii) At the level of Thinking, Decision Making and Acting, however, it is where we can recognize, the most profound differences, because such difference become corresponding *facts*.

In this respect, some preliminary considerations (presented in Giannantoni 2012) were specifically focused on the design of some artificial systems.

Now, however, because of the particular importance of such concepts, the latter will be reconsidered with specific reference to the relationships between Man and the Environment, precisely because of their completely different and profound related consequences.

Basic Differences with Specific Reference to the Relationships between Man and The Environment

i) The basic difference at the level of "Thinking" resides in the fact that the Traditional Approach starts from the adoption of "aprioristic presuppositions". These "necessarily" lead to its persistent conception of any system as a pure "mechanism" and, at the same time, at modeling, designing and establishing any form of "relationship" (of any nature) *always* in "functional terms".

The Generative Approach, on the contrary, precisely because starts from recognizing the "Emerging Quality" of "Self-organizing System", adopts "*new mental categories*", which result as being *a posteriori*, because they are conform to the "Emerging Quality" *previously* recognized.

In this way the Generative Approach is always *orientated* at conceiving any form of "Relationship" with the Environment (in its widest sense) so as to maximize the Harmony between any subsequent action and the "Emerging Quality" *previously* recognized. That is, it is orientated, from the very beginning, at establishing all the future Relationships in "Ordinal terms" and, possibly, at the maximum level of Ordinality;

ii) At the level of "Decision Making" the two Approaches will evidently make decisions (that will become consequential future *actions*) in a perfect *conformity* with their respectively different way of thinking: on the one hand, in conformity with "aprioristic" presuppositions; on the other hand, in conformity with the *new mental categories* adopted "a posteriori". Consequently, in both cases, in perfect *conformity* with their specific models of the *surrounding habitat* adopted.

iii) At the level of Action, however, it is exactly *where* we can recognize the most marked differences between the two Approaches, because, in this case, their specific differences *become* consequential *facts* (see Giannantoni and Zoli, 2010c).

In extreme synthesis, we can say that the specific difference (more widely illustrated in Giannnatoni 2014) strictly depends on the fact the Traditional Approach is always orientated at *isolating* a specific aspect of the problem, by loosing, in this way, the perception of the Whole and its associated "Emerging Quality". In other words, it operates a "*previous selection*" or, more radically, an "*aprioristic cut*" of the phenomenology under consideration. So that it only focuses on a limited "part" of the System and, consequently, even if it achieves appropriate results, some "side effects" can always appear. The latter, in fact, are generally due to the contributions of all the other parts of the System not initially considered as being "involved" in the process analyzed.

This preliminary choice does not simply means that there might be a "quantitative distance" between foreseen and expected results but, even more, the same choice revels the presence of a "*conceptual distance*" with respect to the System analyzed, basically referable to the above-mentioned "previous selection" aprioristically operated. Such a "conceptual distance" is precisely that which can lead to those consequences previously termed as "*side effects*".

In the case of the Generative Approach, vice versa, even if the considered System is initially modeled as being (only ideally) "isolated" from the remaining parts of the Universe, it is always considered as a *Whole*, *from the same formulation of its mathematical model*. This is because any "Self-Organizing System" is always modeled as "emerging" from a Generative Process, characterized by its specific Ordinality. Such a description always leads to "Emerging Solutions" that, in turn, reflect the "Excess of Quality" associated to the self-Organizing System each time considered.

In addition, it is worth considering that, in the case of an Ordinal Interaction between two different Systems, the "Emerging Solution" of the new System so generated is characterized by a higher level of Ordinality with respect to the "sum" of the Ordinalities of the two initial Systems. This means that, by taking into account that all the other Systems, not explicitly considered in such an Interaction Process, are *always* "Self-Organizing Systems", we have to expect some "extra contributions", in term of "Emerging Quality" and corresponding increasing level of Ordinality.

This is because all "Self-Organizing Systems" always behave according to the M.O.P. Consequently, their possible contributions, although not foreseeable in advance (because not

initially modeled) are always in "consonance" with the "Emerging Solutions" obtained with respect to the sole Systems really modeled in actual fact.

This conclusion is perfectly conform to the enunciation of the Maximum Ordinality Principle, which verbally assert that: "Every System tends to maximize its Ordinality, *including that of its surrounding habitat*".

This is also the reason why such "extra" contributions have been termed as "Emerging Exits" (Giannantoni 2012), also because they generally manifest themselves as "Extra Benefits".

CONCLUSION: A COMPOSSIBLE APPROACH TO MODERN SCIENCE

The conclusion is synthetically reproduced in Tab. 2, which shows that, *beside* the Traditional Approach, which affirms that "Every System is a *mechanism*" (at a phenomenological level), there is also a new Com-possible Approach, according to which: "*Every System is a Self-Organizing System*" (always at a phenomenological level).

The two Approaches, although deeply different, are however always Com-possible. Nonetheless, while the former present *Unsolvable Problems*, *Intractable Problems* and *Problems with "drift*" (which always represent an indication of "side effects"), the Generative Approach does not suffer from such problems, whereas, in addition, presents several advantages.

In fact, as anticipated in the title of the paper, the New Approach is based on the "Emerging Quality" of "Self-Organizing Systems". It is precisely such an "*Emerging Quality*" that, when modeled according to the Maximum Ordinality Principle, is able to offer *a radically New Perspective* to Modern Science. That is: "*Every System is a Self-Organizing System*".
This is because the New Perspective:
i) starts from considering the "Emerging Quality" of Self-Organizing Systems as an "*Irreducible Excess*";
ii) then, in a perfect adherence, introduces a new formal language, the *Incipient Differential Calculus*, which is properly apt at describing the "Emerging Quality" of Self-Organizing Systems;
iii) in this way it succeeds in formulating a very general Principle, the Maximum Ordinality Principle (M.O.P.), which can be understood as "*One Sole Reference*" Principle;

Every System is a "Mechanism" **(at a phenomenological level)**	**Every System is a "Self- Organizing System"** **(at a phenomenological level)**
Basic Presuppositions	***"Emerging Quality"* of Self-Organizing Systems**
1) causality principle (efficient causality) 2) classical logic (necessary logic) 3) functional relationships	1') Generative Causality 2') Adherent Logic 3') Ordinal Relationships
The associated formal language	**Development of an appropriate Language**
d / dt translates the three fundamental presupposition $f(t)$ represents a *functional relationship*	- L. Boltzmann, A. Lotka - H. T. Odum: Emergy Algebra and M. Em-P. P. - Further developments in transient conditions - Introduction of the "Incipient" derivative $\tilde{d}/\tilde{d}t$
The traditional description is given in terms of **- Thermodynamic Principles (1st , 2nd, 3rd)** **- Physical Laws (specific for each Discipline)** **i) Unsolvable Problems** **ii) Intractable Problems** **iii) Problems with "drift", which are always an indication of** **"side effects"**	**The Maximum Ordinality Principle** ***as one sole reference Principle*** **a) Applicable to *any* Field of analysis: *non-living* Systems, *living* Systems, "*thinking*" Systems (e.g. Human Systems)** **b) At *any space-time scale* and in *variable conditions*** **c) The corresponding Solutions are always explicit** **d) There are not Unsolvable or Intractable Problems** **e) A possible Ordinal "Drift" is an indication of** **"Emerging Exits" (Extra Benefits)**

Tab. 2 - Synoptic picture of the Two Com-possible Approaches to Modern Science

iv) The latter in fact results as being valid *in any field* of analysis (from *non-living* Systems, to *living* Systems and *human social* Systems too), precisely because it is able to describe the "Emerging Quality" of any "Self-Organizing System";
v) In addition, the new formal language adopted *always* leads to *explicit solutions*;
vi) At *any topological scale* (e.g. from atoms to galaxies);
vii) Both *under steady state and variable conditions*;
viii) What's more, the corresponding Solutions to any mathematical model based on the M.O.P. are always "Emerging Solutions", in the sense that their *Ordinal Information content* is always much higher than the Ordinal content corresponding to the initial formulation of the problem;
ix) Such a particular aspect represents the main reason for having termed the above-mentioned Principle as the Principle of "Maximum Ordinality" and, at the same time, the basic reason why the latter is able to describe the "Emerging Quality" of "Self-Organizing Systems";
x) This is because the M.O.P. is able to describe the *Self-Organizing Capacity* of any given System by means of its *specific* and *characterizing* form of Generativity, which is precisely that which gives origin to the *Self-Organization* of the System as a *Whole*, in terms of Ordinal Relationships;
xi) Moreover, such Relationships, precisely because described by means of "Emerging Solutions", can never be reduced to mere "functional relationships";
xii) This is also the reason why the M.O.P. is radically different from the traditional Physical Laws or Thermodynamic Principles usually adopted by traditional Modern Science. The M.O.P., in fact, does not operate in terms of "logical necessity" and/or "efficient causality";
xiii) This consequently means that any solution can never be considered as being "*a particular case*" of a general Principle (such as in the case of Classical Thermodynamics), precisely because any solution represents a *new* "Emerging Solution", characterized by it specific "originality";
xiv) At the same time, the M.O.P. does not require specific references to any sort of "forces" (or other "causes") to describe a given System, because any System is modeled with reference to its *Self-Organizing Generative Capacity*, which is the "source" of its specific "Emerging Quality";
xv) Said in more general terms, the M.O.P *does not require any* specific reference to the traditional Physical Laws or to the well-known Thermodynamic Principles;
xvi) What's more, the M.O.P. never lead to "side effects". This is because, even when its "Emerging Solutions" might manifest some correlated "Emerging Exits", the latter can always be interpreted as being related "Extra Benefits";
xvii) Such an interpretation, as already anticipated, is perfectly conform to *the same enunciation* of the Maximum Ordinality Principle, which asserts that:

"*Every System tends to maximize its Ordinality, including that of its surrounding habitat*".

xviii) For all these reasons, we can conclude that, according to such a New Perspective:

"*Every System is a Self-Organizing System*".

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www.ordinality.org: author's website that presents a general framework about the M.O.P, from the Mathematical Formulation of the Maximum Em-Power Principle up to the Mathematical Formulation of the M.O.P., together with some Ostensive Examples mentioned in this paper.