Can Real Life Complex Systems Be Interpreted with the Usual Dualist Physicalist Epistemology - Or is a Holistic Approach Necessary ?

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Abstract:
It is being recognized that the reductionist materialist paradigm of modern science is not pertinent to understand self-organizing systems evolving toward increasing complexity and autonomy, like living, cognitive and conscious systems. We present here a brief description of a non materialist systemic metamodel, or language, that takes not only actual matter into account but also potential relations and existential whole. This extension of the mechanist science is not expressed by mathematical equations but by a set of graphical patterns describing the spontaneous self-organization of natural systems, their evolution toward complexity and autonomy and the conditions of viability. Another communication presents an application to the case of present day society and its possible futures.

Keywords:
general systems approach, non-physicalist holistic epistemology, framework for complexification and autonomization

1. Introduction

We take the opportunity of the theme proposed for this Congress, "The System in its Context", to draw the attention on the existence and the importance of the ontological and epistemological context on which any scientific description, model or theory is based. Mainstream science is presently built on the assumptions of the mechanist paradigm which holds that reality is made up of material objects moving in space and time according to precise and eternal laws governing the movement of things. This vision has been with us for about three centuries and we have naturalized it so deeply that we take it for granted and are not aware of its presence and its influence on our scientific theories, our values, our Weltanschauung, our behavior and actions – and our problems.

The rise of this empirico-analytical paradigm – named in accordance with its dualist foundation: a) the visible existence of the material world, and b) the assumed existence of laws that determine its movements – followed the fall of the perverted scholastic paradigm, based on the Christian theology and the Aristotelian philosophy, in the 17th and 18th centuries. The elaboration of mechanics, the science of movement, and later of chemistry, physics, of the science of electricity and magnetism, was followed by the invention of technical devices and by the industrial production of goods and equipement that profoundly transformed our environment and facilitated the peoples' daily life. Reductionist empirico-analytical science is particularly efficient in the description of simple and separable objects, mainly inorganic substances. Its many successes made believe that it could be applied with similar success to the more complex situations met in living, ecological, socio-economical and cognitive systems. However, a closer look around us shows that the positive impact of science, technology and associated business

is not uniformly distributed and that its collateral negative effects on the general population now tend to increase.

A second motivation for this communication is our conviction that the standard approaches in the humanities and the social sciences – sociology, economy, political science, psychology, anthropology, etc – normally used to understand and handle the increasingly numerous problems of today's society, are inadequate – or to say the least, insufficient - to interpret complex multidimensional situations. Several new structures and processes like:

- the non linear configurations characterized by networks of interconnected positive and negative feedback loops, leading to self-regulation or self-organization processes
- the growth of structures triggered by both the necessities imposed by the environmental constraints and the presence of random fluctuations (like chaotic systems),
- the emergence of partially autonomous biological, social and bio-cybernetical entities,

cannot be described by mechanics and the sciences still influenced by the mechanist linear way of thinking which are perfect to make a watch or design an automobile. Needless to say that the too anthropocentric "soft" sciences and the traditional approaches to deal with human affairs, like religions or political ideologies (liberalism, socialism, etc.) are also insufficient to identify the pertinent logic, the chains of causalitiy responsible for the occurrence of the observed events.

The 11-September attack is not an isolated event but only one of the latest challenging problems of the last decade. The cascade of unexpected events and undesired trends in several fields – collapse of the planned economy in Eastern Europe, discovery of the extent of corruption in market economy, globalization of the economy, increasing importance of the commercial and financial dimensions, the recent instabilities in world stock exchanges at the expense of the democratic decisions, privatization of the commons, increased gap between riches and poor within the countries and between countries, confrontations between Western civilization and other cultures, to mention only a few – shows that our representation of the dynamics of living, social and techno-economical systems is far from adequate.

We are convinced that a substantial improvement in our view of nature and society will not be reached by elaborating more refined dualist scientific theories or more detailed numerical simulations only. Indeed, the very ontological and epistemological presuppositions on which present day science stands should, it seems to us, be seriously discussed and critically questioned. We present in this paper, as a contribution to this effort, a new framework, more general than the Cartesian-Newtonian mechanist approach, that should be more fit to interpret complex (partially) autonomous systems.

2. Presuppositions of Mainstream Science

Before presenting our metamodel, let us recall the main ontological and epistemological presuppositions of mainstream dualist empirico-analytical science and of contemporary common sense:
realism (there is an independent reality there, in front of us),
materialism (reality is ultimately made out of matter),
ontological dualism and determinism (there are two worlds: 1, the usual world of the real movements of the material things in space and time (Cartesian res extensa) and: 2,. the

world of ideas (Cartesian res cogitans), in particular the mathematical world of the invariant equations that determine these movements. The philosophers still struggle about the nature of the connection between these two worlds.
ontological reductionism and atomism (every thing in the world is composed ultimately of small pieces of matter from which one can deduce all the properties of the things),
objectivism and separability - between objects, between object and subject (observer), between the material movements and the immaterial mathematical laws).

In summary, objectivism holds that there is a given reality in front of us, this reality is material and the changes which take place there are determined by quantitative laws which man can discover by the use of reason (the reason is built on the respect of the three principles of the Aristotelian logic).

3. The Main Features of the Proposed Holistic Epistemological Context

In the continuation of this paper, we present the main features of a more general onto-epistemological framework, useful - or eventually necessary - to understand real life complex systems, with non-linear and self-organizing features, which evolve toward increased complexity and autonomy; this type of systems are commonly found in living, ecological, social, economical, cognitive, and, a fortiori, in hybrid mixed situations. Unlike the usual scientific approach, ours does not take only the actual material structures into account but also the immanent network of virtual relations that generate the possible future states of the system. This onto-epistemological framework a) is not dualist but holistic (because actual movements and corresponding laws form an inseparable whole) and b) is not determinist, since systems – or sub-systems - can be autonomous, in the sense that they do not always follow predetermined laws of movements (which is in our view a degenerate case), but can produce themselves the laws that rule them. Knowledge of the separated parts is not sufficient to know the properties of the whole system, and, unfortunately, due to the absence of an independent reality, objectivity does not hold, which makes it hard to accept for many scientists.

The purpose of our metamodel [Schwarz (1997)] is not to describe things like in mechanics, i.e. pre-existing objects (atoms in physics, individuals in social sciences); but to describe systems, i.e. more or less complex entities defined as sets of several (at least two) interacting parts. Therefore our starting point consists of the three inseparable primal categories present in all systems: objects, relations and wholes; these three types of initial ingredients are on equal footing – in particular relations which are as "real" as objects. Our metamodel is therefore an extension of the mechanist paradigm where objects have a privileged ontological status.

The second basis of our model concerns the dynamics of systems, it consists of a dual principle governing change in nature, this principle can be seen as a dialectical oscillation between two processes: a drift toward disorder and a capacity to increase order through self-organization. More precisely, the first part of this principle, the drift toward disorder, is the well known trend of an isolated physical system to reach its most probable state, which is measured by the maximum of its entropy; this trend is associated with the category of objects. The second part of our principle, the capacity to self-organize, is due to the existence of an obstacle to the trend toward the most probable configuration. This obstacle is the presence of circular loops in the immanent network of causality within the system; this capacity is associated to the category of relations. As the complexity of the system increases, this feature, also called operational closure [Maturana and Varela, 1980], can lead successively to self-organization, self-production (autopoiesis), self-

reference and finally, autonomy. As we shall see, self-organization is the source of morphogenesis or creation of structures, autopoiesis is interpreted by Maturana and Varela as the logic of life, the source of the overall coherence of the living organisms. We have proposed that self-reference is at the root of consciousness [Schwarz (1997)].

From these foundations, we obtain a metamodel - a generic model to make specific models - consisting of three patterns describing the dynamic of natural systems: 1) A spiral pattern for the four successive phases of self-organization (morphogenesis, self-regulation, entropic drift, and bifurcation to a qualitatively different state). 2) A pattern for the long term evolution toward complexity and autonomy. 3) A pattern formed by six cycles which describes the functioning of viable systems.

Our metamodel is a general epistemological framework through which detailed models can be built for particular complex situations, as can be met in ecology, in biology, in social sciences or in cognitive sciences. These systems are not only characterizd by dense networks of interactions, feedback loops, emergence of new structures (chaotic non linear systems), high sensitivity to noise, but, more fundamentally, we suspect that, in principle, they cannot be understood in the dualist paradigm where it is supposed that the changes can be computed by a permanent set of invariant equations as can be done in astronomy for example. In complex systems, the equations themselves change with the changes in the concrete system. In these cases we propose that a completely different approach be used, which goes beyond the Cartesian dualist pair (res extensa and res cogitans) and reaches the holistic level of existence.

An important difference between the mechanist epistemology and ours is the nature of the relations. In mechanics, due to its materialistic prejudice, Newton's force between two masses (and the other forces discovered later) have been interpreted in quantum mechanics by the exchange of material particles (gravitons, photons, etc): the only reality is matter-energy; the concept of relation is not part of the mechanist reality. In our metamodel, matter-energy is only one aspect of what exists, the other being the immaterial network of potential relations immanent in the material structures. In simple cases like in celestial mechanics this network can be approximated by the usual invariant laws of movement. But in nonlinear systems and, a fortiori, in social, living and thinking systems, the material structures and the ever changing networks of potential relations – which conditions the evolution of the system - cannot be separated and must be taken together at all times in one holistic entity.

As we see, the notion of relation is hard to situate in the mechanist framework. Even more difficult to apprehend scientifically are the concepts of whole, of existence or of being, which are traditionally associated to religion and philosophy, or, in the best case, to the "soft" sciences. Whatever their names, science now needs meta-mechanist notions that refer to a system as a whole and to its holistic, unitary and existential characteristics. We hope our metamodel is a useful step in this direction.

Several applications of this generalized epistemology have already been done [Schwarz (2002a) and references in there]. In another paper proposed to this Congress [Schwarz (2002b)], we try to interpret the present state of our techno-economical society and build some possible scenarios for its future.

4. Brief Description of the Holistic Metamodel

4.1. Primordial Categories and Prototypical System

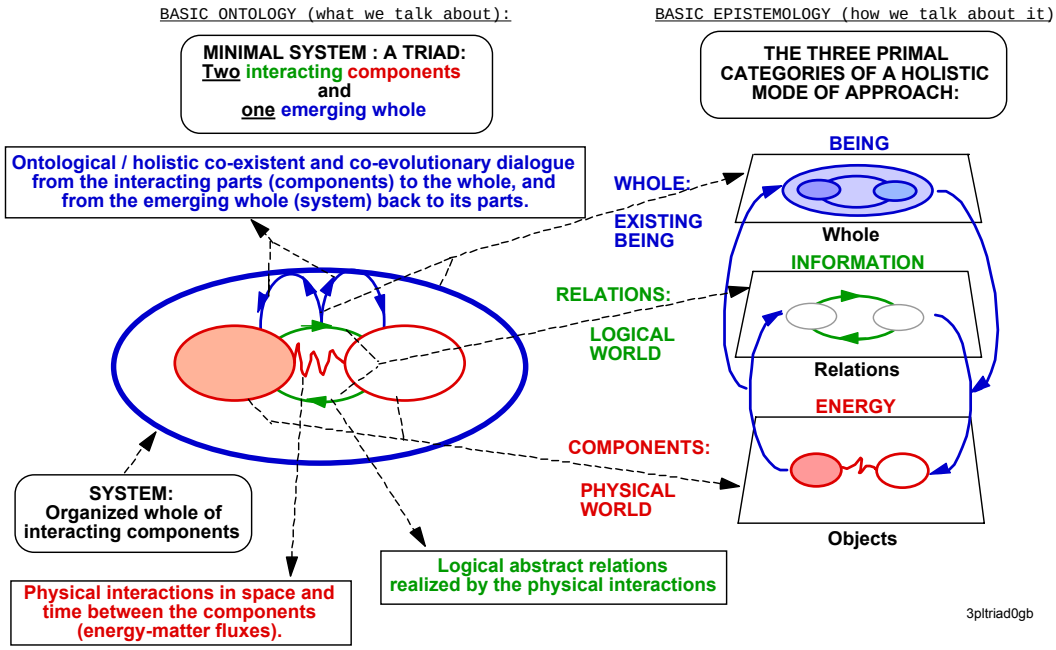


Fig.1. The basic entity which is the generic object described in our metamodel is the minimal system: a triad, i.e. a non-separable whole of two interacting components (ontology). The corresponding epistemology has therefore three primal categories: the physical world of objects (components), the abstract world of relations (images of interactions), and the existing world of the whole which is, the system.

Searching for the most general configuration of things when we observe nature, we propose a most simple and general system made up of two components in relation (see left of fig.1). It can represent either any pair of interacting objects or a subject observing an object. Drawing the conclusions from this trivial starting point, we propose that any existing situation, is given by couples of interacting components, which constitute an existential whole, a "system". As can be seen in the prototypical system on the left of fig.1. we distinguish the actual physical interactions between the two parts and the potential relations that may not be actualized.

As already mentioned, the usual Cartesian-Newtonian dualist view of an objective "reality" whose evolution is determined by some eternal "laws", is replaced here by a holistic approach where what happens emerges from a deep ontological dialogue between two inseparable and nevertheless irreducible aspects (see right side of fig.1.): the physical world of the things, which we can perceive by our senses and which corresponds to the usual world of physics (energy plane), and the cybernetical world of the potential relations immanent in the system (information plane), one of which can be actualized during the next round in the dynamics of the system. This potential field can be symbolized in the framework of a theory by symbols or algorithms, like numbers, parameters, differential equations, logical reasoning or geometrical figures. But one should not confuse the symbols of a theory, which are human artifacts, and the immanent potential relations in the system, which are part of nature. The permanent ontological dialogue between the real physical aspect of the system and its virtual potentialities is represented on the right side of fig.1 by the loop connecting the physical plane and the information plane and its integration in the system as an existing whole (plane of being).

4.2. The Spiral of Self-Organization

The next question for our metamodel is the problem of dynamics: how does a system emerge, how does change occur ?

We mentioned already that the basic source of change in nature is the interplay between two opposite and nevertheless constructive processes: entropic drift toward disorder and uniformity, and self-organization, bringing order. By observing the birth and dynamics of a wide variety of real life systems, we conclude that, practically, the interplay between these two opposite/cooperative processes leads to the succession of four stages which frequently follow a state of instability in some parent system (see fig.2.):
Tensions. precursor tensions as last stage of the life of the preceding system and source of instability (non linear conditions far from equilibrium)
Alea. noise or fluctuations (alea), able to trigger a positive feedback loop, which leads to
Morphogenesis. a cascade of mutually provoked events (self-organization by positive feedback loops), which ends up in a state of:
Stability: a new dynamically stable structure-organization of the newly emerged system, followed by a
Tropic Drift. a phase of actualization of the potentialities or propensions of this new system (entropic drift or trend toward the more probable).

These stages correspond to the four sectors of the spiral of fig.2. It must be noticed that the fluctuations in the alea sector do not always lead to a new viable configuration (branch c) but, more often, end up with the destruction of the system (b), or eventually with its continuation accompanied by minor adjustments (a).

4.3. The Six Cycles of viable systems

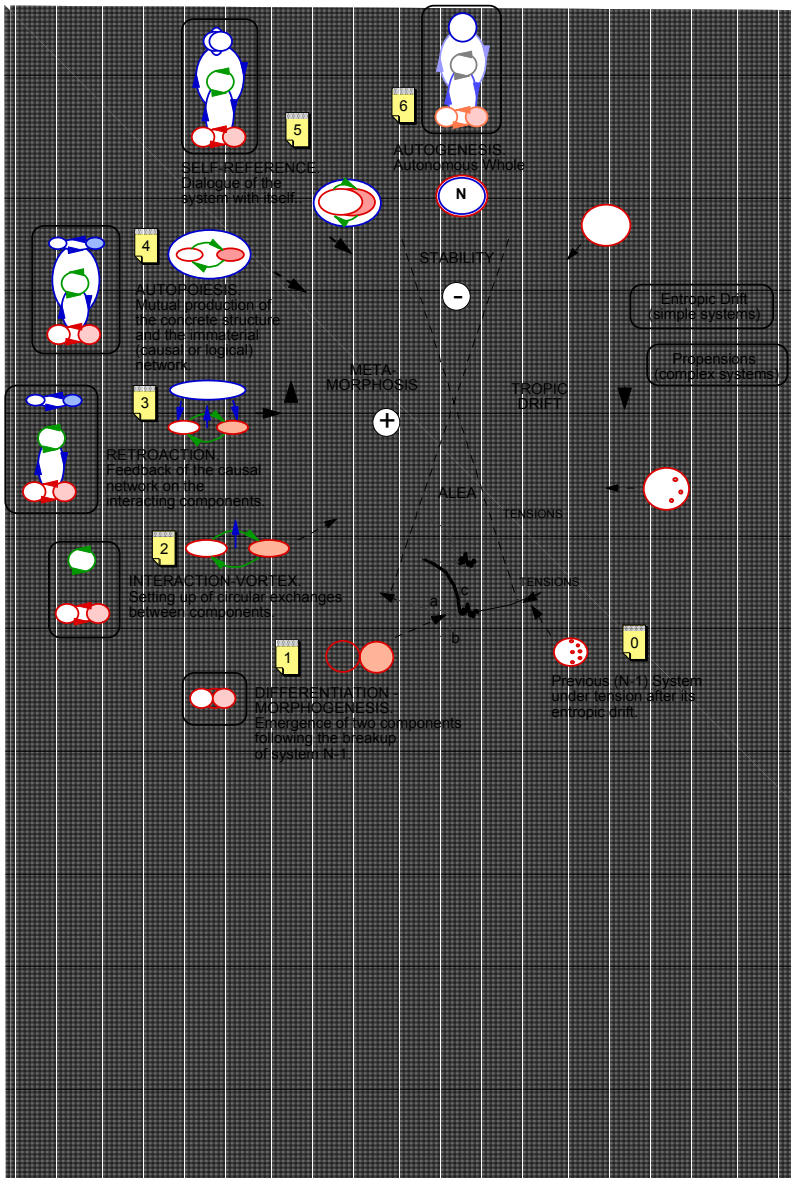
A closer study of these processes shows that the iteration of several such spiral cycles generates a long term evolution toward ever more complex and autonomous systems, characterized by the successive appearance of six circular relations of increasing abstraction. These six logical cycles can also be represented on the spiral pattern since they can be interpreted as higher level aspects of morphogenesis toward complexity and autonomy. We complete the above short description of the six cycles by the following comments.

0) The entropic drift of the medium is the natural trend of the preceding (parent) system, which may drive it far from its stable point ("far from equilibrium"), where a fluctuation can be amplified and start a catastrophic cascade of changes. This natural drift corresponds to the trend toward the more probable formalized by the increase of entropy for the most simple systems; for more complex cases this same drift can be more adequately called actualization of potentialities or Popperian propensions..

1) Morphogenesis. The first of the six cycles can be visualized as a positive feedback loop between two (or several) mutually produced variables or parameters of the medium far from equilibrium, with the effect of differentiating the medium (dissipative structures, cancerous cells or demographic proliferation for example).

2) Vortices. The second cycle is a physical cycle in space and time, like vortices in a moving fluid, ecological recycling of matter, or oscillations like heartbeats. A valid relation must be circular; it is the first necessary condition for perennity.

3) Feedback, Homeostasis. The next step in the development of a viable system is the possibility of being stable. This feature requires the compatibility between the fluxes and exchanges in the physical plane (vortices, physiology) and the corresponding network of causality, that can be seen as an abstract image of the concrete processes. The regulating feedback loop belongs to the relational, or cybernetical plane.



4) Autopoiesis. When a homeostatic system complexifies for hundreds of millions of years as was the case for the prebiotic evolution, it may reach a level where there is not only compatibility between the physical structure and the logical organization, but also self-production: the organism incarnates a causality network which produces the organism that incarnated it. This new super-circularity, called autopoïesis and proposed by Maturana and Varela (Zeleny 1981) is pictured here as a loop that connects the physical plane and the relational plane. A self-producing (= autopoïetic) system is an entity that, as a whole, produces itself by an adequate dialogue between its organic structure (and material fluxes) and its own network of causality. This step corresponds to the logic of life.

5) Self-reference. Autopoïesis is the beginning of self-reference: the system is its own reference. The system is operationally closed; a completely autopoïetic system does not need any logical connection with the outside. In the picture, self-reference is symbolized by the overlapping between the object and the image, the two terms in relation in the holistic plane. The object can be seen as the organism (the brain, for example) and the image as the immaterial network ("the mind" in traditional parlance). In this metamodel,

the degree of self-reference of a system is interpreted as its level of self-knowledge, which means its level of consciousness.

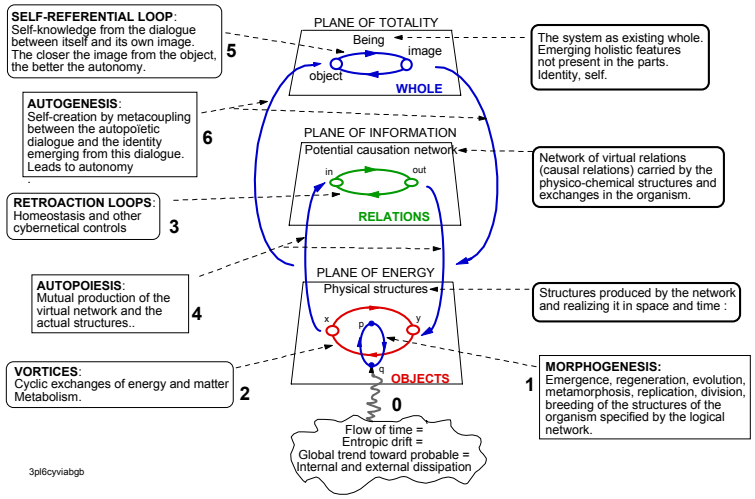


fig.3. The six cycles defining viable natural systems, in the three physical, relational and existent
The three "horizontal" cycles (vortices (2), homeostasis (3), and self-reference (5)) inside the three planes are responsible for the stability of the system; the three "vertical" cycles between the planes (morphogenesis (1), autopoïesis (4) and autogenesis(6)) are responsible for the changes. For human beings, the respective places of the brain, the mind and consciousness are also found.

6) Autogenesis**.** The ultimate cycle represents the impact of the system as a whole on its producing (= autopoietic) dialogue; in other words, autogenesis, or self-creation, is what makes a system autonomous: an autonomous system is able to create its own laws. Autogenesis is pictured in fig.2. as a loop that connects the system as a whole in the existential plane and its own self-producing (autopoietic) process. A strictly autonomous system is operationnally closed: it has absolutely no logical connection with the outside world. The actual systems and sub-systems forming the Earth living system are only partially autonomous systems and therefore need each other..

At the end of its development, a system includes all six cycles that guarantee its viability as represented in fig.3. The six little framed icons on the left side of the spiral in fig.2. symbolize the successive "switching on" of each of these logical circle.

Let us notice that three cycles contribute to the stability of the system: vortices (recycling of matter), retroaction (self-regulation) and self-reference (road to autonomy); the other three cycles, self-organization (morphogenesis), self-production (autopoiesis) and self-creation (autogenesis) insure the capacity to change that also contributes to the survival capacity of the system as an identity.

5. Concluding Remarks

We have presented a systemic language more adapted to interpret complex and autonomous systems than the usual empirico-analytical mechanist sciences. This language or metamodel extend the ontological and epistemological presuppositions of the conventional materialist reductionist paradigm. It is based on three inseparable and irreducible primal categories: substance or objects (which corresponds to the usual "reality" of materialist science), relations (which can be associated with the clasical notions of information, of mathematical forms, of mind) and existential whole, which subsumes both objects and relations and can be crucial to interpret notions and experience like that of consciousness.

Since objects and relations cannot be separated, this holistic – non dualist – framework questions the traditional method and purpose of science: to discover the "laws of nature"

and to be able to make predictions and therefore control our environment. However, by producing a meta-context, the "big picture", it can help to situate ourselves in this general context and therefore to give meaning to real life processes and historical events. That is what will be tried in another paper to this congress where we try to apply this metamodel to the present situation of modern society and to its possible futures.

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