The Quantal Architecture of Natural Systems

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Abstract

We are at a point now where the overall profile of Cosmic evolution is becoming discernible. In what follows, its broad outline is suggested. It is made as generic as possible, in order to encompass the processes of energy transformation from the birthing event of the cosmos to the present. To this effect, the paper is presented from the most general point of view, i.e. taking an energy stance, on the grounds that energy is the ultimate substrate of all there is.

At the core of it are two distinguishable elements: the elementary processes of energy transformation that result in the emergence of new systems, and their modal character which governs their diversification.

Key Words: Cosmic Evolution, Energy, Modality, Enabling Relation, Natural System

1 Introductory Remarks

It is best to preface this paper with a short lexicon of useful notions, as well as with a list of the main assumptions that support scientific discourse.

(i) The importance of the *lexicon* lies in pinning down the sense given to the key terms used in what is to follow, because the generality of the present discourse might easily lead to misconstruals.

• The *global* and the *local*: the first is purely conceptual while the second is ultimately sensorial. Observation is a mix of the two, the former being projected onto the other. There is no case where the one is got without the other in the context of the sciences of nature.

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• The *Quantum Vacuum* is to be construed here as the *energy substrate* of the whole universe. In particular, its *fluctuations* are the source of all processes of energy transformation, the sequence of which is constitutive of the evolutionary character of the observable universe.

• The *Universal Energy Gradient* denotes the progressively diminishing energy density associated with the expansive phase of the observable universe. It goes from the big bang to the present, and a global measure of it is given by the so-called background radiation, now ~2.7°K.

• The notion of *Modality* is grounded in the set of traces interactions leave in the observation plane.

• *Laws of Nature* represent patterns of observable events which remain invariant in all similar modal contexts.

• *Symmetries* are features of the laws of nature which can be expressed by means of symmetry groups[1]. They characterise modal domains from the theoretical point of view. Modal changes are accompanied by breaks in the symmetry properties of the laws nature[2].

• *Space-Time* denotes the dimensional context wherein all observations are made.

• The notion of *Natural System* is used to refer to any localised complex energy hierarchy whose evolution can be traced back to the initial materialisation of the so-called elementary particles in the primal field. Natural Systems are *stratified*, their identity being observed in their emergent characteristics.

(ii) The importance of the *assumptions* is due to the role they play in defining the conceptual framework wherein the argument of the paper is deployed .

• The observable world is *evolutionary* in character: i.e. it is essentially dynamic and unfolds in Space-Time, an energy context characterised by a progressively decreasing density, the consequence of its expansion.

• The basic constituents of the world are processes of *energy transformation* rather than localised objects , such as galaxies, organisms, atoms, etc, which are their consequences.

• The dynamical processes of energy transformation are *quantum computational* in nature.

• *Observations* are theory laden, the result of the ordering of information (e.g. data points) in accordance with (i) practical criteria elaborated in the preparation of the specific context of observation, and (ii) with specific conceptual criteria[3].

• The underlying *structure of the linear processes of energy transformation* is best represented by means of an algebraical structure defined over an observation space, where it functions as the syntax of the language of nature.

2 The Elementary Theory of Natural Systems

2.1 In the sciences of matter, for example in physics, the ordering of the underlying structure is achieved by *projecting* a *conceptual* framework onto an assumed *ideal phase space,* while the ordering of what is *perceived* is achieved by *projecting* the *conceptual* dimension of that framework onto the *observation space*. The first projection is required by the geometrical character of the underlying phase space, while the observation level is mapped by defining a corresponding algebra on that space. In this way, the syntactical structure which underlies the resulting language can be used both to articulate a theoretical model and to order the information found at the observational level. The phenomena are thereby woven out of the same conceptual cloth as the model, an essential feature of the relevance of theory to what is observed.

It is assumed that the underlying structure of phenomena is such that some dimensions of the phase space correspond to the set of discrete events which Shannon might call *information*. If, however, every dimension of the phase space correspond to data, then these are ordered by a conceptual model which transforms it into *intelligence*. When so structured, the corresponding phenomenologies are *structure specific*, in this respect unlike the expressions of ordinary language which are object oriented (This accounts for the dependence of the sciences of matter on mathematical syntaxes, which goes back to the development of analytical mathematics by Fermat, Descartes, Leibniz, Newton and their successors).

Nature thus represented displays the following *characteristics*: it is (i) dynamical, i.e. energetic, (ii) evolutionary, i.e. historical, (iii) holistic, i.e. non local, (iv) stratified, i.e. quantal.

(i) The *dynamical character* justifies the energy stance, whose generality makes possible a generic representation of the anatomy of nature.

(ii) The *evolutionary character*, understood energetically, is borne out by the *sequence* of processes of energy transformation which begins with the birthing event of the observable cosmos and goes to the present. These processes are the ontological constituents of nature.

(iii) The *holistic character* of nature is a consequence of phase relations grounded in the quantal nature of all energy transformations. It is a symptom of the unity of nature.

(iv) The *stratified character* of nature is a consequence of the dual character of energy

transactions. It is apparent in the discontinuities observed in the conversions of *energy* between its global and local forms, a condition often referred to as the wave-particle duality. The effects of multi-modal sequences of such processes in the decreasing context of energy density are the evolution and the diversification of natural systems.

2.2 Quantum Mechanics differs from those that preceded it in one important respect: energy is neither exclusively radiant nor corpuscular[4]. Experimentally, *radiant energy* materialises under certain circumstances which are known, though the underlying process is not well understood at this time. How radiant energy suddenly condenses in one place (e.g. as in pair production) is a profound mystery, the only one in quantum mechanics according to Feynman. Sometimes the materialisation occurs spontaneously, other times in particular interactive contexts (such as a measurement). Equally mysterious is the reverse process, whereby *condensed energy* dematerialises and radiates, as in the case of the annihilation of positronium into two gamma rays under conservative constraints.

The conversion of radiant energy into matter is never total, as is shown by the entanglement of particles which is mediated by their conjugate modal field. This was in fact the assumption of both de Broglie and Schrödinger, the originators of wave mechanics. Two broad categories of particles play a role in quantum mechanics: *real* and *virtual*. Real particles produce phenomena in their local environment which may be field like or particle like depending of the context of their interactions with their environment. Virtual particles leave no observable traces and therefore do not produce phenomena, thus not observable. They belong to the underlying structure of phenomena as modelled by the theory and include the *field particles,*. Elementary particles, e.g. quarks and electrons, which are real, are generally thought to have initially materialised as the result of interactions by the virtual particles that emerged from local fluctuations of the *quantum vacuum*, the universal substrate which sustains and energizes the material universe[5].

These two forms of energy, *radiant* and *corpuscular*, are never completely isolated from the rest of the universe, some fields having an infinite range. Clearly, this is a non classical situation, one which Einstein mistakenly thought of as rather far fetched. And yet the empirical evidence points to the quantal character of the physical domain of observation, where all processes of energy transformation occur. This is a radically different world from the one in which we have our being.

2.3 This raises a question about the origin of this lack of perceptive acuity regarding the quantum world, especially if we consider that the mechanisms of energy transformation are all quantal in nature, and that our own perceptual system operates entirely within the domain of quantum events, as is becoming abundantly clear from the recent literature[6,7,8,9].

A possible answer may be found in two important facts. The first is that *all natural systems* are self organised and evolve from the high energy end, where elementary particles interact, to the low energy of their emergent level, where complex systems display their modal (or submodal) identity[10]. These modal strata are gauged on specific threshold values of the energy density of their

local environment[11], the separation between one modal level and the next being marked by an *energy gap* or *Heisenberg Cut*[12] which is opaque to observation. The interactive processes which are observed in the emergent domain thus differ from those which are internal to the system and energize it[13]. Yet, the enablement of the emergent system is not in doubt.

Therein comes the second relevant fact: a *different type of causal relation* specific to quantum physics, to be called here the *enabling relation*, effectively links the two modal domains, the one *internal* to the system and the emergent one, which is *external* to it. It is functionally and structurally different from the linear causal relations observed in classical interactive contexts, in that it spans *two distinct modal domains*, each with its *own type* of empirical evidence. Each one of these distinct types of data is ordered by modal *laws of nature* specific to it which reveal significant symmetry differences which effectively rule out the possibility of a common observation space and, by the way of consequence, rule out the simulation of the enablement relation by means of digital computations, which exploit the properties of recursive functions[14]. For example, cognitive processes are radically different from the neurological processes that enable the human brain to cognize, and are irreducible to them. This phenomenon accounts for the aforementioned lack of perceptive acuity about quantum processes.

2.4 Two distinct types of energy processes are found in the self-organisation of natural systems: those that are linear and those that aren't. We shall begin with those of the first kind.

Linear processes found in the self organisation of natural systems may be grouped under two distinct though related headings: *interactions* and *entanglements*.

(a) *Interactive* processes will be represented here as

$$\psi(\mathbf{a})\oplus\psi(\mathbf{b}) \Longrightarrow \psi'(\mathbf{a})\oplus\psi'(\mathbf{b}) \qquad (1)$$

where $\oplus$ is made to denote a *scattering functor*, and **a** and **b** stand for the interacting systems. In suitable circumstances, interactive processes lead to an entanglement of the particles.

(b) Processes of *entanglement* may be symbolised here as

$$\psi(\mathbf{a})\otimes\psi(\mathbf{b}) \Longrightarrow \psi'(\mathbf{a},\mathbf{b}) \qquad (2)$$

where $\otimes$ is made to denote an *entanglement functor* acting on each system's wave function. This leads in natural systems to the ultimate *closure* of all linear processes by way of cyclical or hyper-cyclical entanglements[15], it also leads to a loss of degrees of freedom for the entangled particles, whence the name given to this process. The end result is the emergence of an energy boundary $\mathbf{B}(\Sigma|\mathscr{E})$ separating the inside of a new system Σ from its outside or environment $\mathscr{E}$.

Non-Linear energy boundaries $\mathbf{B}(\Sigma|\mathscr{E})$ sport pairs of *endogeneous* characteristics on their environment side, which may be symbolised as

$$\Pi(\Sigma) = \{\pi_i\} \tag{3}$$

and

$$\mathscr{F}(\Sigma) = \{f_i\} \tag{4}$$

Here, $\Pi(\Sigma) = \{\pi_i\}$ denotes the set of *intrinsic endogeneous characteristics* sited on the emergent system Σ, such as modal charges and spins, while $\mathscr{F}(\Sigma) = \{f_i\}$ denotes the set of their *conjugate modal fields* which define the modal environment $\mathscr{E}(\Sigma)$ by transforming the *initial* (i.e. pre Σ- emergent) *local energy profile* $\mathscr{F}(\mathbf{E})$ into the post emergent one by the superposition of the modal fields in the surround of Σ, this being the essence of their *adaptive strategy*:

$$\mathscr{F}(\Sigma)\otimes\mathscr{F}(\mathbf{E}) \Longrightarrow \mathscr{E}(\Sigma) \tag{5}$$

The conjugate characteristics therefore define the modal, i.e. the energy identity of Σ in $\mathscr{E}(\Sigma)$, and by way of consequence, the symmetries of their interactions.

To recap: the principal results of the elementary theory, and its originality, are to be found in the properties and functions of the energy boundary $\mathbf{B}(\Sigma|\mathscr{E})$. The most important and original of these is the *bridging* of the energy gap or *Heisenberg Cut* $(\Sigma|\mathscr{E})$ and its philosophical conjugate, the *enabling causal relation*[16].

The structure of this physical process emerged, in full mathematical regalia, from the work of Walter Schempp on the quantum mechanical substrate of Nuclear Magnetic Resonance Imaging, or MRI for short. This is the mathematical theory of *quantum holography* whose applications are found in all natural systems, where they represent the critical function of bridging the energy gap[17,18].

3 The Modalities

The notion of *modality* has its observational basis in the symmetry properties of the laws that govern linear interactive processes between particles, expressed through their Lagrangians. Modalities are therefore manifestations of the irreducible character of these laws to those on the other side of the Heisenberg cut[19].

Modal fields are naturally *gauged* at their high energy end on specific values of the *Universal Energy Gradient* which extends *in Space-Time* from the big bang to the present. By contrast, their

low energy end is determined by the structural nature of their modality, more specifically by that of their field particles. Some, such as the strong nuclear modality or the weak nuclear modality, have a very narrow range in space- time, while others, such as the electro-magnetic modality, whose field particle, the photon, has zero mass, have a potentially infinite range in space-time.

The characteristics of modal fields: (i) the *nature of the interactions* which provide the observational basis for their operational reality, (ii) the *dependence of their onset* on a specific value of the local energy density, and (iii) their *range* in space time, are *criteria of modalisation* pointing to *life* and to *cognition* as modal fields, on a par with the more familiar ones previously mentioned. Although this may seem strange, it is consistent with the generic dynamical architecture of natural systems, which are all products of material, i.e. *cosmic,* evolution.

Modalities also play a role in the *lateral complexification* of natural systems which branch out *within* the range of a broad modal band and are the sources of its *fine modal structure*. This is a domain of observation much investigated by naturalists concerned with evolution, e.g. Darwinists, wherein the nature of the environment, being effected by the local superposition of the modal fields, determines the particulars of the *local* energy profile[20]. However, unlike the Darwinist view of evolution, the environment $\mathscr{E}(\Sigma)$ is molded by the modal characteristics of the systems in it, and not the other way around.

4 Coda

One last point about the notion of perceptual acuity mentioned in the first part. There is some indication, from a number of sources, that we are approaching a time when the means to represent the unfolding of the observable universe, both physical and mathematical, and the structure of the brain, are all isomorphic[21]. More will be said elsewhere on this topic which requires longer deployments.

The presentation of this paper has been improved by the judicious comments of my learned colleague Professor Patrick Heelan. Although our philosophical perspectives differ somewhat in the significance we give to the role of the observer in establishing the objectivity of the phenomena, there is no divergence of view on the nature of the observables, e.g. on that of information, nor on the nature of the intelligence got from it by the projection of the conceptual framework onto the observation plane, however mediated this process may be.

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