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Universal Dynamic Complexity, Its Conservation and Development as Unified Order of the World[†]

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ABSTRACT. The unreduced, universally nonperturbative analysis of a generic system of arbitrary interacting entities leads to the absolutely universal and reality-based concept of dynamic complexity expressing the revealed qualitatively new phenomenon of dynamic multivaluedness of emerging incompatible (redundant) versions of interaction results called system realisations. Thus developing holistic hierarchy of world complexity represents the unified dynamical Order of the World adequately described by proposed universal equations and naturally combining causal randomness of realisation emergence and predictability of their probability distribution. That rigorously specified description reproduces the observed reality in full detail, without any artificial “mysteries” inherent in canonical science and at all levels, starting from elementary particles and up to living beings, consciousness and all products of its activity. Conceptual problems of teleology, ethics, aesthetics and Creation, as well as practical problems of modern civilisation, are provided with causally consistent solutions demonstrating the obtained extension of canonical science and theology up to the intrinsically complete and unified form of knowledge called universal science of complexity. Such qualitatively new kind of knowledge based on the causally complete, totally realistic and consistent understanding of Being is indispensable for the inevitably forthcoming transition to the superior level of civilisation development directly leading to the causally specified noosphere and genuine “knowledge-based society”.

KEY WORDS: dynamic redundance, entanglement, causal randomness, a priori probability definition, dynamical chaos, self-organisation, dynamical fractal, intrinsic creativity, symmetry of complexity, universal science of complexity, causally complete understanding, René Descartes, Louis de Broglie, Pierre Teilhard de Chardin, noosphere, knowledge-based society, criterion of progress

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1. Unreduced interaction as universal source of creation

Any real existence of an entity (including a universe), both “tangible” (or “material”) and “imaginary” (or “spiritual”) one, is determined by a structural inhomogeneity (or simply structure), since a strictly homogeneous “entity” would be equivalent to non-existence. Inhomogeneous structure of a real entity necessarily involves different, but “closely” connected elements, so that it cannot be reduced to their mechanical, “separable” superposition (otherwise one would deal with many independent entities that can only formally be unified into a single one). Interconnected elements can be called interacting ones. Therefore any really existing entity involves internal interaction(s) determining its very existence.

Applying this result to “this”, perceived world as a whole, we see that its causally complete, first-principles picture should start from consideration of interaction process in the simplest possible system of two real, a priori homogeneous (structureless), and therefore “extended”, entities, or “(proto)fields” (Kirilyuk 1997). Taking into account the observed properties of eventually emerging world structures, one is forced to assume that one of the protofields is of electromagnetic origin and directly perceivable (only in the form of its perturbations produced by the protofield interaction), while another, directly unobservable one constitutes a qualitatively different (but equally real) gravitational medium/protofield (since it is responsible for emerging gravity transmission). Thus specified material origin of participants of the most fundamental, “driving” interaction of our world constitutes the *single* (unavoidable), and *physically* based, “postulate” of a causally complete description: by using the unreduced, universally nonperturbative analysis of interaction process development, we rigorously show that all the observed world structures, starting from elementary particles and up to the most involved patterns of conscious brain activity, naturally and progressively *emerge* by (in principle) autonomous hierarchic unfolding of that fundamental interaction between the two protofields (Kirilyuk 1997, 1999a,b,c).

This *intrinsic* property of unreduced *creativity* within all existing entities emphasises the essential difference of thus obtained picture, called *universal science of complexity*, from the canonical science framework, including both “old” (classical) science and its attempted “extensions” of “new physics” (quantum mechanics, relativity, etc.), “post-modern” variations of the latter, or official “science of complexity”, that *cannot* consistently *derive* any qualitatively new object/property it operates with and is forced therefore to artificially insert them, in the form of empirical facts, formal postulates, mathematical constructions, or speculative “principles”. Correspondingly, nothing can really change (appear or disappear) in that conventional world presentation, where, in sharp contrast to observations, always “tout est donné”, as it was acutely noted by Bergson (1907). A qualitatively different, self-developing, and thus *naturally creative* picture of the universal science of complexity is based on a conceptually new phenomenon of *dynamic redundance*, or *multivaluedness* and related *dynamic (physical) entanglement* of interaction components. These key features are derived within the *unreduced* description of arbitrary interaction by the “method of effective dynamical functions” (Kirilyuk 1992, 1996, 1997, 1999a,b,c) being the universally nonperturbative extension of the known “method of optical (effective) potential”.

Dynamic redundance means that any real, unreduced interaction (e. g. protofield attraction) produces a redundant (excessive) number of *real* system configurations, which are *incompatible* among them and forced therefore to *permanently replace* one another in a *causally random* order. Indeed, if each of two interacting entities (e. g. protofields) possesses N eigen-modes (or “structural elements”) in its “free state”, then the result of unrestricted interaction should evidently involve N^2 versions of their entanglement. However, those interaction products exist in the same reality as “free” interacting entities, with the same number of N places for them, which gives the N -fold redundance of interaction products. This transparent conclusion confirmed by the detailed analysis (Kirilyuk 1992, 1996, 1997, 1999a,b,c) has been omitted in canonical science because of its invariably reductive, perturbative approach oriented to obtaining an “exact”, closed (totally disentangled, or “separable”) problem solution that corresponds to mechanistic “joining together” (“superposition” or transposition) of interacting entities, preserving their initial number, N , unchanged (i.e. no additional entity can actually emerge).

Products of unreduced interaction-entanglement constitute thus N incompatible (redundant) system configurations, so that each of them totally occupies the whole relevant “place” in reality (i. e. completely represents the compound system) and is called therefore system *realisation*. Those *equivalent* solution-realizations, *explicitly obtained* in the unreduced analysis, have strictly “equal rights” and therefore should appear, replacing each other, in a *causally random (probabilistic, unpredictable)* order, which provides the *purely dynamic*, universal, and omnipresent *origin of randomness* in the world and an analytically derived, *a priori* value of *probability* of each realisation emergence (it is evidently equal to $1/N$ in the simplest case of homogeneous interaction partners).

Explicitly obtained *realisation emergence* provides a causally complete extension of the notion of *event*, and therefore the *dynamically random* realisation change process gives physically specified, *naturally irreversible* and *unceasingly flowing time*. *Dynamic (physically real) entanglement* of interacting entities creates tangible “texture” (physical *quality*) of each emerging realisation and thus forms an element (finite-size “point”) of *emerging, tangible* structure of dynamically “woven” tissue of *space*. That dynamical “weaving” of space from interacting entities is due to *unceasing* transitions between redundant system realizations, during which interaction components should also *disentangle* from a current realisation before being again entangled in the next realisation (Kirilyuk 1997, 1999a,b,c). In particular, the unceasing cycles of dynamic entanglement-disentanglement of interacting primal protofields produce the *material* tissue of basic, “embedding” physical space with its exactly *three* “dimensions” emerging as a dynamical mixture of *three* participating real entities (two protofields plus the coupling interaction as such), while the corresponding fundamental time flow, “paced” by unceasing protofield entanglement-disentanglement *events*, characterises physically real *actions* (of realisation change), rather than a tangible, material entity, or “dimension”.

The unreduced *dynamic complexity* can be consistently and *universally* defined as a growing function of total realisation number, or their rate of change, equal to zero for the (unrealistic) limiting case of only one realisation. Examples of such *complexity measures* are provided by (generalised) *entropy* defined as logarithm of (dynamically derived) realisation number, *mass-energy* defined as the temporal rate of realisation change, or *momentum* defined as its spatial rate (Kirilyuk 1997, 1999a,b,c). *Dynamical chaos*, characterising causal randomness in the sequence of system realisation appearance, is just another expression for dynamically *complex* behaviour of *any* real system with interaction. It can appear in various *regimes* continuously varying between a small number of limiting cases (*uniform chaos*, *multivalued self-organisation*, or *self-organised criticality*, and *turbulence*) that encompass *all* observed patterns and *always* contain inseparable dynamic *mixture* of randomness (of each realisation emergence) and order/regularity (of causally derived realisation probability distribution).

Since unreduced interaction naturally forms a *hierarchy* of discrete levels (emerging interaction products start interacting again to form the next level, etc.), the same refers to dynamic complexity that exists as intrinsically unified, naturally developing *hierarchy (arborescence) of complexity* of the world. The first, most fundamental level of complexity emerges in the unreduced interaction of two protofields as elementary particles causally explained as *spatially chaotic processes* of essentially nonlinear *quantum beat* (periodic cycles of local reduction-entanglement and extension-disentanglement of the coupled protofields) endowed with intrinsic (dynamical) “wave-particle duality” and “quantum indeterminacy”, permitting us to eliminate all “weirdness” and “mysteries” of canonical quantum mechanics and extend it to intrinsic unification with causally derived relativity (Kirilyuk 1997, 1999a,b,c).

Dynamically continuous but extremely nonuniform process of hierarchic interaction development provides causal extension of the notion of *fractal*, which acquires realistic, dynamic, and *causally probabilistic* character, being obtained as the *general solution* of a main dynamic equation. Therefore that *dynamical fractal* incorporates existing structures and processes of *any* type and not only explicitly “fuzzy” patterns *imitated* (or “modelled”) by usual, single-valued and abstract “fractal sets”. It is clear that the above *causal time and space*, constituting the basic *forms of unreduced dynamic complexity* and determined by changing realizations, repeat the multi-level fractal structure of complexity, where “ordinary”, quasi-homogeneous space and time are *causally produced* at the first level by quantum beat dynamics of the coupled protofield system.

2. Universal dynamic symmetry of unfolding complexity and transition to unified, causally complete knowledge

The most important property of intrinsically unified, first-principles world design of unreduced science of complexity — and also its key distinction from any canonical, single-valued theory — is the natural, irreducible *progress (creation)*, in the form of autonomous complexity development into a hierarchy of permanently changing realisations (forming both “objects” and their “dynamics”). That causally specified “creative evolution” (Bergson 1907) is described by the *absolutely universal law of conservation and transformation, or symmetry, of complexity*, where the *total, always conserved*, amount of dynamic complexity, C , is obtained as a sum of two different, *permanently changing* parts, where a “potential”, “latent”, or “folded” complexity form, called *dynamic information, I*, is unceasingly transformed, as a result of interaction, into a “realised”, “explicit”, or “unfolded” complexity form of *dynamic entropy, S*, so that the quantity of entropy permanently grows at the expense of equally diminishing information: $C = I + S$; $C, I, S > 0$; $\Delta C = 0$, $\Delta S = -\Delta I > 0$.

Our generalised, dynamic entropy, information and complexity are universally defined, always *positive* and *physically real* quantities derived *analytically* by *interaction analysis* and obeying basic *dynamic* equations, contrary to their various canonical imitations (Kirilyuk 1997). Thus, a universal measure of (always dropping) dynamic information I is provided by *generalised action, \mathcal{A}* , whereas the local temporal rate of its decrease in the course of interaction process development (a “differential” complexity measure) gives *generalised (total) energy, $E = -\partial \mathcal{A} / \partial t$* (Kirilyuk 1997, 1999a,b,c).

It can be shown (Kirilyuk 1997) that the universal complexity conservation law is the unified extension of all canonical, empirically postulated “conservation laws” (conservation of energy, mass, momentum, charge, etc.) and “principles” (e.g. of entropy increase, relativity, least action, or any other manifestation of the “variational principle”) and is supported therefore by the *ensemble* of observations confirming all canonical laws and principles. Due to the dynamically *changing*, creative “internal structure” of the universal symmetry of complexity, it can be expressed as a unified dynamical equation of system *change (or evolution)*, being complex-dynamic extension of usual Hamilton-Jacobi equation. That universal equation exists in two related forms, a local version (generalised Lagrange/Hamilton approach) and nonlocal version (generalised Schrödinger equation), which are reduced, in corresponding particular cases, to all known dynamical equations (though in their extended, dynamically multivalued version) describing either generalised system “trajectory” (now multivalued and randomly changing) or its probabilistic “distribution (or wave-) function” (Kirilyuk 1997).

Universal complexity unfolding as a result of interaction development has a transparent physical interpretation: both information and entropy represent dynamic complexity of redundant realisations, described by any its suitable measure, but information is a system complexity at the very beginning of its interaction development (or “generalised potential energy”), whereas entropy is a “developed” structure complexity that emerges in the course of interaction process and reaches its (local) maximum at the end of interaction development, after which the system cannot progressively evolve as such, finishes its active *life* (the latter being now *universally* defined), and soon *dies* in the attained state of generalised *equilibrium* (that still contains chaotic fluctuations). This causally complete interpretation of any real process reveals conceptually important extension of usual “second law of thermodynamics” (principle of entropy increase) by the universal symmetry complexity: now *any* interaction process, and not only those of explicit “structure degradation”, is consistently described as *increase* of generalised entropy characterising *any structure creation*, which corresponds to the fact that, by contrast to the oversimplified reduction of usual, dynamically single-valued science, *any* real structure (object) is obtained as a *probability* distribution of its *randomly* changing realisations, which are but sufficiently similar to each other for externally “regular” structures (patterns of behaviour) and sufficiently different for externally “irregular” (or “chaotic”) structures.

Moreover, instead of unpleasantly asymmetric “degradation” (of energy) in usual theory we obtain now the underlying *conservation* of total complexity equivalent to the universal dynamic *symmetry* of *developing* complexity that provides explicitly the unified dynamic *Order of the World* (including its mathematical expression by the above Hamilton-Schrödinger formalism and accompanying causally complete general solution in the form of self-developing dynamical fractal). This unreduced symmetry of reality is quite different from any mechanistic “identification symmetry” of canonical science, as it shows that more “intricate”, inimitably “irregular” and chaotically changing structures are usually *more* ordered (symmetric) than those looking more regular but having *lower dynamic complexity*, whereas a totally regular pattern (evolution) has zero complexity and thus unrealistically low dynamical order. Contrary to any mechanistic symmetry of usual science, the universal symmetry of complexity is always *dynamically maintained* by permanent system *transitions* between its *symmetric* (but generally quite *dissimilar*) states formed by realisations and levels of complexity.

Growth of unreduced dynamic complexity (in the form of generalised entropy) in the course of its autonomous unfolding from the hidden form of dynamic information represents the universal criterion, definition, and direction of *progress* at any level of existence that cannot be consistently derived within the canonical, single-valued science paradigm in principle. Any real system, including the world as a whole, should first be explicitly *created* from “outside”, in the form of dynamic information realised as interacting primal entities (like the two protofields for our world) “put into (first) contact”. Then the system starts to develop, or unfold, this “potential” (but real) complexity into its explicit, “replete” (and chaotically moving) spatial structure described by generalised dynamic entropy. The dynamic redundancy phenomenon explains why and how this *distributed creation* process can be *autonomous*, in principle, even though occasional “corrections of complexity”, exerted from outside at some “critical” moments, can be useful and are suitably facilitated by *redundant realisation instability*.

These results of the universal science of complexity resolve problems around *Creation* in both canonical science and theology extending them to the unified, causally complete *understanding* of the world design. The world cannot “spontaneously” appear, or “tunnel”, from a “vacuum state”, as it is permitted by mechanistic energy conservation of canonical science, since this is *not* permitted by conservation of unreduced world complexity, which is always positive and “as big as the world”, taking into account irreducible dynamic irregularity (causal randomness) within *any* real entity, as opposed to the reduced energy notion of unrealistic, intrinsically *regular* “models” of canonical, single-valued cosmology. On the other hand, one does not need to impose a “momentary” Creation of the world in its most ordered, perfectly developed form, as it is implied by *both* canonical religion/theology *and* conventional “law of energy degradation”, but can replace it by the *distributed, quasi-autonomous, self-developing structure creation* described above as unceasing, but nonuniform transformation of indeed explicitly created (coming from the outside) dynamic information (generalised potential energy) into dynamic entropy (the observed world structure).

The result of distributed creation, the *unified diversity* of Being, unsuccessfully sought for within the fundamentally deficient single-valued paradigm of canonical knowledge, is naturally incorporated into the very basis of the causally complete description in the form of *dynamic redundancy* phenomenon. It is equivalent to every system splitting into many different and “independent” (locally complete), but dynamically related “branches”/realisations, revealed simply due to the unreduced, totally consistent analysis of arbitrary interaction process avoiding any deceptive simplification of perturbative, effectively one-dimensional approach of usual theory. All existing structures and phenomena, from “mysteriously” *dualistic* elementary particles to the phenomenon of *life, consciousness* and all products of the latter, can now be *consistently understood* and adequately, realistically described as entities from certain, well-specified and naturally discrete *levels of unreduced dynamic complexity* (Kirilyuk 1997).

The naturally emerging notion of dynamic information and its inevitable transformation into the tangible, observed structure of reality provides the universal, causally specified solution for *teleological* problems: development of *explicitly created* stock of informational, “potential” interaction complexity (in

the form of initial system configuration) into its most involved, unfolded form of entropy represents the universal objective and subjective “purpose” and “aim” of any system, and we show how this aim can be autonomously, dynamically achieved by the system due to its autonomous splitting into fractal hierarchy of incompatible realisations. In particular, our dynamic information provides causally specified extension of such apparently “inexact” notions of canonical knowledge as “desire” (“intention”), “motivation” (“faith”), or the famous Bergsonian “*élan vital*” (Bergson 1907).

The related *ethical* and *aesthetic* problems are fundamentally solved in the universal science of complexity through the causally complete interpretation of the corresponding basic notions: *good* is objectively defined as *increase* of unreduced complexity-entropy (also providing the universal criterion of *progress*, see above) determined by the growing number of *real* possibilities/realisations, and *evil* is the absence of good appearing as persisting stagnation of system development related to excessive domination of relatively low complexity levels, whereas *beauty*, or *harmony* (of a system) is defined by the *attained* (given) level of unreduced complexity-entropy, usually with respect to, and in interaction with, another complex system playing the role of “estimator”/“connoisseur” (Kirilyuk 1997). These *causally complete* interpretations of basic ethical and aesthetic notions based upon the universal concept of dynamic complexity of *unreduced interaction* process are confirmed by the totally consistent system of correlations with the *whole diversity* of properties of real complex, most often “living”, “conscious”, and “social” systems. In particular, we see that good can be objectively described as a growing level (progress) of harmony (beauty), which provides the fundamentally specified confirmation of the expected relation between ethical and aesthetic values. Civilisation complexity growth, representing the universal, causally specified progress of good, provides the general *raison d'etre* of human civilisation, including both the *sense of history* and “super-goal” of further, “post-historical” development, showing why indeed (the growing) “beauty will save the world” as noted by the famous Russian writer Fyodor Dostoevsky.

Many-sided analysis of modern civilisation state shows (Kirilyuk 1997) that right now it is objectively brought to an extremely large-scale, unavoidable *transition* towards a superior, qualitatively different level of complexity (of thinking and living) that can be consistently understood and efficiently monitored *only* within the new, causally complete approach of the unreduced science of complexity. Providing causal interpretation of canonical Apocalyptic predictions and their various modern versions, this result shows also that fundamentally based, universal conclusions of the new approach are *practically important* not only for solution of stagnating scientific problems (see above), but also for solution of “global”, “meta-scientific” problems of civilisation development as a whole that *cannot* be divided into canonical “fields“ of science, technology, economy, art, philosophy, or theology. A related example is provided by the *ecological* aspect of the same fundamentally substantiated transition leading to the concept of *creative ecology* (Kirilyuk 1999d) that can be considered as the unreduced causal extension of the idea of *noosphere*, in a remarkable agreement with the theological/philosophical picture of life and consciousness development outlined by Pierre Teilhard de Chardin ([1955] 1974).

The natural synthesis and extension, within the universal science of complexity, of various branches of knowledge that can be as different as canonical science and theology involves not only causally complete, transparent solutions to many stagnating problems, but also a general *qualitative advance of knowledge* that can be designated as *extended causality*. It means that within that new, *truly conscious* kind of knowledge man can really *master* the *irreducibly complex* (dynamically multivalued) world he lives in by achieving the *intrinsically complete*, totally sufficient *understanding* of reality as a whole and in any part. This self-developing understanding of the *genuine reality* is basically accessible to *everybody* due to intrinsic causality (realism) of the new knowledge, expressing its permanent connection with the unreduced reality that should replace the current stagnation and “professional” isolation of scholar knowledge becoming the more and more abstract. The extended causality of the universal science of complexity has a number of great precursors, such as René Descartes (in foundation of modern science), Louis de Broglie (in causal fundamental physics), and Pierre Teilhard de Chardin (in theology and philosophy), but their clear attachment to the unreduced complexity of various levels of reality has

always been misunderstood and effectively suppressed by dominating simplification of “one-dimensional” (single-valued), or “mechanistic”, thinking. Today, however, that invariably single-valued approach of canonical knowledge has totally exhausted its possibilities, and the natural civilisation evolution has inevitably brought it to the point after which it can either disappear in a series of various catastrophic falls, or continue its unrestricted development at a *qualitatively higher* level of *irreducibly creative* living (it has nothing to do with, and actually is opposed to, the currently dominating mechanistic, superficially calculative and “technocratic” imitation of progress and knowledge).

We conclude with the statement, supported by the outlined detailed content of the universal science of complexity, that such qualitatively big transition to the *well-specified* superior kind of knowledge possessing the *intrinsic*, “inbred” universality and “interdisciplinarity” in its very basis is *indispensable* for the forthcoming stage of civilisation development towards the *knowledge-based society*, which *cannot* be attained “gradually”, by simple *quantitative* increase of educational efforts using conventional, exhausted kind of knowledge and intense imposition of general “good ideas” about “transdisciplinary convergence of knowledge”, etc. The desired quality of knowledge is well known and basically never changes since the beginning of scientific/philosophical thought that has always been oriented to the most complete understanding of Being. What remains now is to transform the accumulated “good intentions” and really big new technology possibilities into a *well-specified content* of knowledge which, being an intrinsic part of unreduced reality, should be *totally coherent* within itself and with any other part of reality. While this condition is not and can never be fulfilled at the basically restricted level of usual, dynamically single-valued science, we have demonstrated above how and why it is fulfilled in the unreduced approach of the universal science of complexity.

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