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Causally Complete Higgsless Theory from Complex Dynamics of Unreduced Interaction

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Introduction of a new physical entity, the omnipresent Higgs field and bosons, in the Standard Model of elementary particles and interactions is related to the absence of the universal dynamical origin of particle mass in this standard description, which is compensated for by particle interaction with the Higgs field. In this paper we propose an extended review of the theory of complex dynamics of unreduced interaction in multicomponent systems, which provides such universal dynamic and intrinsic origin of mass appearing, in the case of elementary particles, together with particles themselves. The same complex-dynamic interaction in the initial minimal system of two homogeneous protofields accounts also for the emergence of all other internal and dynamical particle properties and fundamental interactions (now dynamically unified). We consider particular advantages of such complex-dynamic origin of mass as compared to the Higgs mechanism and propose the respective Higgsless interpretation of recent experimental results of the “Higgs boson discovery” at the Large Hadron Collider. Finally, we formulate the necessary essential changes of the entire strategy of research in high-energy physics and fundamental physics in general, following from the obtained results.

Уведення у Стандартній моделі елементарних часток та взаємодій нової фізичної сутності, усюдищого поля й бозонів Хіггса, пов'язане з відсутністю у цьому стандартному опису універсального динамічного джерела маси часток, яка й надолужується за рахунок їх взаємодій з полем Хіггса. У цій праці ми пропонуємо розширений огляд теорії складної динаміки нередукованої взаємодії у багатокomпонентних системах, яка надає таке універсальне динамічне і внутрішнє джерело маси що з'являється у випадку елементарних часток разом з самими частками. Та ж сама складно-динамічна взаємодія у початковій мінімальній системі двох однорідних протополів пояснює виникнення й усіх інших внутрішніх і динамічних властивостей часток та їх фундаментальних взаємодій (тепер динамічно об'єднаних). Ми

розглядаємо конкретні переваги такого складно-динамічного джерела маси у порівнянні з механізмом Хіггса і пропонуємо відповідну безхіггсову інтерпретацію недавніх експериментальних результатів із “відкриття бозона Хіггса” на Великому адронному колайдері. На закінчення ми формулюємо необхідні суттєві змінення усієї стратегії досліджень у фізиці високих енергій та фундаментальній фізиці в цілому, які впливають із одержаних результатів.

Введение в Стандартной модели элементарных частиц и взаимодействий новой физической сущности, вездесущего поля и бозонов Хиггса, связано с отсутствием в этом стандартном описании универсального динамического источника массы частиц, которое и восполняется их взаимодействием с полем Хиггса. В данной работе мы даём расширенный обзор теории сложной динамики нередуцированного взаимодействия в многокомпонентных системах, которая предлагает такой универсальный динамический и внутренний источник массы, появляющийся в случае элементарных частиц вместе с самими частицами. То же сложно-динамическое взаимодействие в исходной минимальной системе двух однородных протополей объясняет возникновение и всех остальных внутренних и динамических свойств частиц и их фундаментальных взаимодействий (теперь динамически объединённых). Мы рассматриваем конкретные преимущества такого сложно-динамического источника массы по сравнению с механизмом Хиггса и предлагаем соответствующую безхиггсовую интерпретацию недавних экспериментальных результатов по “обнаружению бозона Хиггса” на Большом адронном колайдере. В заключение мы формулируем вытекающие из этих результатов необходимые изменения всей стратегии исследований в физике высоких энергий и фундаментальной физике в целом.

Key words: many-body problem, complexity, chaos, self-organisation, origin of mass, Higgs field, origin of time, relativity, quantum mechanics, Louis de Broglie, double solution, hidden thermodynamics, hierarchy problem, high-energy physics.

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1. INTRODUCTION

As the standard theory of particles and fields does not propose the universal dynamical origin of mass, it is forced to introduce an additional material entity, the omnipresent “Higgs field” and the constituent “Higgs bosons” [1-6], which interact with initially massless elementary fermions and “brake” the (formally postulated) “symmetry” of respective (abstract-mathematical) fields, explaining their finite inertial mass and therefore the massive, “tangible” nature of all usual, structure-forming matter. The recently discovered weak but noticeable resonance in the spectra of super-high-energy proton collision products [7,8] was correspondingly interpreted as a definite sign of the Higgs boson (instantly splitting into registered more stable particles).

The essential, fundamental and technical problems of such *extrinsic* concept of mass and its Higgs field [9] preserve their “unsolvable” status and become especially evident upon comparison with another, dynamical and universal concept of mass originating in complex dynamics of *unreduced* many-particle (and quasi-continuous media) interaction [9-24].

In this paper we provide the extended analysis and comparison of our complex-dynamical concept of mass (section 2) with the Higgs mechanism of the Standard Model, demonstrating the advantages of the former (section 3) taking into account also its unified solution of major fundamental physics problems (the unified, physically real origin of elementary particles, their internal and dynamic properties, self-consistent cosmology, etc.). The possibility of Higgs field existence itself becomes dubious because of the arising contradictions, whereas the “confirming” experimental data from the Large Hadron Collider [7,8] obtain a new, self-consistent interpretation (comprising in this case also many other experimental observations, which remain unexplained otherwise). Moreover, we state that taking into account field interactions, the real existence of any (macroscopic) scalar, and especially massive, field (such as the Higgs field) is quite improbable (with serious consequences for many usual models).

The obtained distinctions from the standard theory are related to our unreduced many-body interaction analysis [9-24], which does not use any perturbation theory approximation or “exactly solvable models” and provides the universal definition of dynamic complexity of all real world structures, starting from the elementary particles. The emerging extended, causally complete understanding of the microworld structure and dynamics leads to the necessary new strategy of all, experimental and theoretical, researches in high-energy and elementary particle physics (section 4).

2. COMPLEX INTERACTION DYNAMICS AS THE BASIS OF THE UNIFIED ORIGIN OF PARTICLES AND THEIR PROPERTIES

Our purpose is to explicitly obtain (rigorously derive) the observed elementary structures (particles), their intrinsic properties (such as mass), interactions and dynamical properties (quantum and relativistic behaviour) as *dynamical* results of the unreduced interaction process within the *simplest* configuration of the minimum quantity of primordial material entities, without artificial introduction of additional structures for explanation of properties and without postulation of abstract laws and “principles” (let

alone of inexplicable fundamental “mysteries”). By their construction itself, the structures, properties and laws thus derived will automatically have the unified and causally complete (physically real and self-consistent) origin, as opposed to arbitrarily postulated abstract entities and “models” of usual theory (see section 3). Therefore, it is just the complete dynamical structure of non-simplified, real interaction of the minimal set of (observable) entities that provides the key extension from the contradictory abstract-mathematical picture to the intrinsically complete real-dynamical description, where the additional abstract structures postulated in usual theory are replaced by quite real and inevitable manifestations of complex interaction dynamics (with essentially greater rigour of the mathematical description, which does not contain now any incorrect approximations and deviations from observations).

It is easy to see that the omnipresent nature of two and only two observed kinds of interactions and phenomena, known as electromagnetism and gravitation, imposes the minimal configuration of the interaction process underlying our world structure formation in the form of homogeneous (attractive) interaction of two initially homogeneous media, or “proto-fields”, the electromagnetic (e/m) and gravitational ones, which finally give rise (as a result of further interaction development) to the observed structures and phenomena. Of course, as real physical entities, these proto-fields also consist of some interacting micro-components, but since the latter are usually beyond observations within our world, we consider the original protofields to be quasi-homogeneous and derive the observed structures as results of their interaction, while specifying, as far as possible, the internal protofield properties by the analysis of observed elementary structure behaviour.

Such minimum configuration of two interacting protofields is expressed mathematically by the “existence equation”, which simply provides a universal description of this configuration, without any essential limitations [9-24]:

$$\left[h_g(\xi) + V_{eg}(\xi, q) + h_e(q) \right] \Psi(\xi, q) = E \Psi(\xi, q) , \quad (1)$$

where ξ and q express the degrees of freedom (or “variables”) of the gravitational and e/m protofields respectively, $\Psi(\xi, q)$ is the state function of the entire system characterising exhaustively its configuration, $h_g(\xi)$ and $h_e(q)$ are the generalised Hamiltonians of free gravitational and e/m protofields, $V_{eg}(\xi, q)$ is the potential of their (attractive) interaction, and E the total system Hamiltonian eigenvalue, or generalised energy. The latter

and the generalised Hamiltonians can express any suitable measure of the universal dynamic complexity defined below, which in many cases will coincide with extended energy (also rigorously defined below) and its operator function (Hamiltonian). Note that the reduced expression (1) actually comprises more detailed version of interaction between all individual protofield elements [10,17-20,23,24], which can be transformed to the same system of equation (see below).

The Hamiltonian form of this starting description is not a limitation due to its real universality appearing e. g. as the Hamilton-Jacobi equation for classical systems and the Schrödinger equation for quantum systems [10,17-19,23-27]. We also emphasize once again that the universality of our approach prevents us from any a priori concretisation of the interaction potential for the protofields with unknown and directly unobservable internal properties (it can eventually be realised later, as a result of comparison of predictions of this general theoretical description with experimental observations).

It is convenient to analyse the existence equation in terms of eigenmodes of one of the interaction components, the e/m protofield (in its free state), considered to be known:

$$\Psi(\xi, q) = \sum_n \psi_n(\xi) \varphi_n(q), \quad h_e(q) \varphi_n(q) = \varepsilon_n \varphi_n(q), \quad (2)$$

where $\{\varphi_n(q)\}$, $\{\varepsilon_n\}$ is the complete set of (orthonormalised) eigenfunctions and eigenvalues of the free e/m protofield (describing its local excitations). Inserting the expansion (2) into (1) and using the orthonormality of $\{\varphi_n(q)\}$, we obtain the system of equations for coefficients $\psi_n(\xi)$, equivalent to the starting existence equation:

$$\left[h_g(\xi) + V_{nn}(\xi) \right] \psi_n(\xi) + \sum_{n' \neq n} V_{nn'}(\xi) \psi_{n'}(\xi) = \eta_n \psi_n(\xi), \quad (3)$$

where $\eta_n = E - \varepsilon_n$ and $V_{nn'}(\xi)$ are matrix elements of the interaction potential:

$$V_{nn'}(\xi) = \int_{\Omega_q} dq \varphi_n^*(q) V_{eg}(\xi, q) \varphi_{n'}(q).$$

Since in the case of arbitrary interaction the system of equations (3) is as nonintegrable as the starting existence equation (1), usual theory tries to approximate it by “similar”, but integrable and strongly simplified equations with a separable “mean field” interaction, such as

$$\left[h_g(\xi) + V_m(\xi) \right] \psi_n(\xi) = \eta_n \psi_n(\xi) .$$

However, essential individual links between system components are lost here, whereas they just determine the system structure forming capacity reduced in this approximation to trivial reproduction of a given static configuration.

In order to overcome these limitations, we use the *unreduced effective (or optical) potential method* for solution of system (2), where one applies the method of substitution of unknown functions $\psi_n(\xi)$ ($n \neq 0$) into the equation for $\psi_0(\xi)$, the former being already expressed through $\psi_0(\xi)$ from respective system equations with the help of standard Green's functions [10,28,29]. As a result, one obtains just one equation for $\psi_0(\xi)$ to solve of externally "integrable" form, but where the whole unreduced interaction complexity is transferred to the (generally nonlocal) effective potential operator depending, in particular, on the (yet unknown) problem eigenvalues and eigen-solutions of a truncated system of equations [9-29]:

$$\left[h_g(\xi) + V_{\text{eff}}(\xi; \eta) \right] \psi_0(\xi) = \eta \psi_0(\xi), \quad (4)$$

where $\eta \equiv \eta_0$ is the eigenvalue to be found, the *effective potential (EP)* $V_{\text{eff}}(\xi; \eta)$ is given by

$$\begin{aligned} V_{\text{eff}}(\xi; \eta) \psi_0(\xi) = & V_{00}(\xi) \psi_0(\xi) + \\ & V_{0n}(\xi) \psi_{ni}^0(\xi) \int d\xi' \psi_{ni}^{0*}(\xi') V_{n0}(\xi') \psi_0(\xi') \\ + \sum_{n,i} & \frac{\Omega_\xi}{\eta - \eta_{ni}^0 - \varepsilon_{n0}}, \end{aligned} \quad (5)$$

$\{\psi_{ni}^0(\xi)\}$, $\{\eta_{ni}^0\}$ is the complete set of eigenfunctions and eigenvalues for the truncated system of equations (system (3) without the equation for $\psi_0(\xi)$), $\varepsilon_{n0} = \varepsilon_n - \varepsilon_0$, and $n \neq 0$ (also below). Upon solution of the *effective existence equation* (4), other state-function components are expressed through the found $\psi_0(\xi)$ with the help of mentioned Green's functions, and then the total state-function $\Psi(\xi, q)$ is obtained by the initial expansion (2) (see below).

Such problem formulation in terms of unreduced EP (4)-(5) is equivalent to the initial expression of arbitrary many-body interaction (1) or (3) and remains "nonintegrable". Therefore, in order to obtain a "closed" (or "exact") solution, usual approach applies perturbation theory also in the

EP problem formulation [29], where again the entire system of dynamical links is lost, together with the essential qualities of the unreduced solution. However, unlike other problem formulations, the unreduced EP method (4)-(5) can help to reveal those essential qualities of the unreduced solution due to the interaction dynamical structure details entering explicitly into the unreduced EP expression (5).

The above EP dependence on the eigenvalues to be found η is especially important, as it leads to essential *growth of the number of eigen-solutions* of the effective existence equation (4) due to the corresponding growth of the highest power N_{\max} of the characteristic equation for η , which determines the total number of eigen-solutions [10,11,17-19,23-27]:

$$N_{\max} = N_{\xi} (N_q N_{\xi} + 1) = N_{\mathfrak{R}} N_{q\xi} + N_{\xi} , \quad (6)$$

where N_q and N_{ξ} are the numbers of summands in the sums over n and i respectively in (5) (usually $N_q = N_{\xi} = N$, where N is the number of interacting modes of all components or, in general, the number of mode combinations), $N_{q\xi} = N_q N_{\xi}$ is the ordinary eigen-solution number for a physically complete system configuration, and $N_{\mathfrak{R}} = N_{\xi}$ is the number of system *realisations*, i. e. its really emerging, equally probable and different configurations, each of them including the ordinary number of eigen-solutions $N_{q\xi}$ and being incompatible with any other, equally physically complete system realisation.

Equation (6) implies that the unreduced interaction process dynamics consists in *permanent change of equally probable realisations*, consecutively “selected” by the system itself in *causally random* order thus defined. The last summand in (6), describing the reduced number of N_{ξ} eigen-solutions, corresponds to the special, “intermediate” or “main”, system realisation, which is inevitably taken by the system during each transition between two consecutive “regular” realisations (containing the complete set of eigen-solutions), accompanied by transient “disentanglement” of interaction components, which pass by a quasi-free state in this realisation. The last conclusion is confirmed by the reduced number of eigen-solutions constituting the intermediate realisation, which provides the *causally complete, physically real extension of the quantum-mechanical wave function*, as well as of all classical “distribution functions” from statistical theory on corresponding levels of interaction dynamics [10-12,16-20,23-27]. Note that these conclusions and the described *dynamically multivalued* structure of unreduced interaction problem solution are confirmed by the independent graphical problem analysis [10,21].

The value of the *dynamically determined, a priori probability*, α_r , of the *causally random* emergence of the r -th realisation from the complete set of $N_{\mathfrak{R}}$ elementary realisations is rigorously derived in this picture as

$$\alpha_r = \frac{1}{N_{\mathfrak{R}}} , \quad \sum_r \alpha_r = 1 . \quad (7a)$$

This expression is naturally generalised to the case of compound realisations at higher complexity levels, where the r -th realisation contains N_r elementary (not directly observable) realisations:

$$\alpha_r = \frac{N_r}{N_{\mathfrak{R}}} , \quad \sum_r \alpha_r = 1 . \quad (7b)$$

We arrive at the universal and rigorous concept of omnipresent *dynamical chaos* in *any* system behaviour in the form of plural system's realisations (i. e. its "totally developed configurations") permanently replacing each other in dynamically (causally) random, absolutely unpredictable order by the action of the main system interaction, without external or internal noise influence (whose "exponential amplification" constitutes the nature of chaos in usual, *dynamically single-valued* theory, see below). In particular, we obtain the *genuine quantum chaos* concept for quantum systems and interaction processes, where the *true* randomness of (Schrödinger) quantum dynamics obeys the usual correspondence principle in transition to classical chaotic dynamics [10,19,21,23]. It is the important consistency condition inevitably violated in usual chaos theory.

The dual and equivalent notion to that of dynamical chaos, which equally universally characterises the dynamically multivalued result of any real interaction, is provided by the *universal dynamic complexity*, C , defined as any growing function of system realisation number or their change rate, equal to zero for the unrealistic case of only one system realisation (the single case considered in usual theory) [10,19-21,24-27]:

$$C = C(N_{\mathfrak{R}}) , \quad dC/dN_{\mathfrak{R}} > 0 , \quad C(1) = 0 , \quad (8)$$

where, for example, $C(N_{\mathfrak{R}}) = C_0(N_{\mathfrak{R}} - 1)$ or $C(N_{\mathfrak{R}}) = C_0 \ln(N_{\mathfrak{R}})$. In that way, any real world structure is both truly chaotic and dynamically complex ($C > 0$), due to fundamental dynamic multivaluedness.¹

¹ In this universal complexity definition, "realisation" refers to any system realisation, including the special intermediate realisation of the generalised wavefunction (or distribution function) described above, as opposed to our more frequently used narrow meaning

We emphasize that while in any real situation $N_{\text{sr}} > 1$ and practically always $N_{\text{sr}} \gg 1$, any usual description within “exact solution” or perturbation theory framework (including conventional “chaos” and “complexity” concepts) corresponds to the values $N_{\text{sr}} = 1$ and $C = 0$ reflecting the total *absence* of genuine dynamic complexity and randomness (chaoticity) in usual theory, which does not exclude their projective imitations in the form of (always incomplete and contradictory) semi-empirical “signs”. Whereas real, dynamically multivalued interactions and emerging structures (starting from the elementary particles considered in more detail in this paper) are *always* internally chaotic ($N_{\text{sr}} > 1$) and dynamically complex ($C > 0$), their *dynamically single-valued* ($N_{\text{sr}} = 1$), *effectively zero-dimensional (point-like) projections* in usual theory are fundamentally regular and non-complex (we also call such description *unitary*), although externally they may seem “entangled” and “irregular”.

Besides the dynamic multivaluedness of the unreduced solution (9)-(10) (and respective real interaction result), its another fundamental feature (and difference from any usual, unitary description) is the *dynamic entanglement* (or interweaving, or mixing) of interaction components, in the form of intricate, dynamically weighted combination of products of functions depending on the interacting degrees of freedom q and ξ . This property is further amplified due to the multilevel, *dynamically fractal* structure of system splitting into chaotically changing realisations, revealed with the help of the same method of unreduced EP applied now to determination of the unknown solutions $\{\psi_{ni}^0(\xi), \eta_{ni}^0\}$ of the truncated system of equations (see eq. (5)) and the consecutively emerging ever more truncated systems of equations [10,17,20,23,24-27]. The dynamic entanglement constitutes the *rigorous mathematical basis* of the perceived physical *quality* of the emerging structure material, which is totally ignored in the usual, dynamically single-valued theory proposing only abstract, “immaterial” models of real structures. Correspondingly, realisation change occurs through the transient *dynamic disentanglement* of system components in the process of transition through the above intermediate realisation of generalised wavefunction, after which a new version of dynamic entanglement emerges in the form of the next regular (properly developed) system realisation.

of “realisation” (e. g. realisation number N_{sr} in eq. (6)), including only regular, “full-fledged” realisations, containing the complete eigen-solution set. However, this difference can hardly lead to any difficulties because practically always we have $N_{\text{sr}} \gg 1$.

Returning to our particular physical system of two attracting initially homogeneous protofields as the basis of all universe structure formation, we can now specify the emerging configuration for this system (the first-level interaction result). The measured *system density* $\rho(\xi, Q)$ in the unreduced EP formalism (4)-(5) is given, as follows from the above, by the *dynamically probabilistic* sum (marked by the sign \oplus) of all probabilistically changing realisation densities $\rho_r(\xi, Q)$ [10,11,17-20,24]:

$$\rho(\xi, q) \equiv |\Psi(\xi, q)|^2 = \sum_{r=1}^{N_{\mathfrak{R}}} \oplus \rho_r(\xi, q) = \sum_{r=1}^{N_{\mathfrak{R}}} \oplus |\Psi_r(\xi, q)|^2, \quad (9)$$

$$\Psi_r(\xi, q) = \sum_i c_i^r [\varphi_0(q) \Psi_{0i}^r(\xi) + \varphi_n(q) \Psi_{ni'}^0(\xi) \int_{\Omega_\xi} d\xi' \Psi_{ni'}^{0*}(\xi') V_{n0}(\xi') \Psi_{0i}^r(\xi')] + \sum_{n,i'} \frac{\Omega_\xi}{\eta_i^r - \eta_{ni'}^0 - \varepsilon_{n0}} \Bigg], \quad (10)$$

where $n \neq 0$, $\varphi_0(q)$, $\varphi_n(q)$ are the (known) eigenfunctions of the e/m protofield Hamiltonian $h_e(q)$ (see eq. (2)), c_i^r are the state-function realisation matching coefficients related to the causally substantiated and generalised Born rule for realisation probabilities [10,11,17-20,23,24], and $\{\Psi_{0i}^r(\xi), \eta_i^r\}$ is the set of the r -th realisation eigenfunctions and eigenvalues of the effective existence equation (4)-(5).

With the suitable choice of e/m protofield eigenfunctions $\varphi_0(q)$, $\varphi_n(q)$ as narrow peaks corresponding to its real, though maybe practically irresolvable components, it is easy to see from (5), (10) that due to the combined action of cutting integrals in the numerator and resonant denominators each r -th appearing realisation *concentrates* around one of its eigenvalues, η_i^r , naturally interpreted as emerging space coordinate (physically real space element) [10-13,17-20,23,24]. And since, as shown above, complex interaction dynamics consists in permanent realisation change in random order, this result means that the homogeneous protofield attraction leads to unstoppable process of their alternating local contractions (with dynamic entanglement) and extensions (with disentanglement) around different, but close centres chosen by the system at random around certain, also eventually arbitrary positions (separated by greater distances).

This process of *spatially chaotic pulsations*, or (strongly nonlinear) *self-oscillations*, induced in the initially homogeneous system of attracting protofields and rigorously derived in our formalism of unreduced EP, also has a transparent physical interpretation in terms of *intrinsic instability* of such uniform attraction. Indeed, a local fluctuation of higher density of one of the protofields will favour density growth of the other protofield in the same location, which will further amplify the initial density increase of the first protofield, etc. This local squeeze process attains its limit due to the finite compressibility of physically real protofields (due to their respective element repulsion), after which it gives place to the opposite extension towards the quasi-free state, due to the same instability involving neighbouring protofield parts. However, the nontrivial feature of those nonlinear self-oscillations is the *dynamically random* choice of each next centre of the catastrophically growing protofield squeeze, or collapse, which was rigorously derived due to the unreduced interaction analysis by the generalised EP method and plays the key role in the *universal Higgsless origin of mass* of elementary particles and thus all other objects (see below).

We call each such local, *spatially chaotic* self-oscillation process in the system of coupled protofields *quantum beat* and show that it constitutes the dynamical structure and source of observed physical properties of (massive) *elementary particles*, or (now intrinsically dualistic) *field-particles*, such as the electron [10-13,17-20,23,24]. Compound particles include several such variously coupled and mixed processes (quark structure of hadrons). Note that quantum beat possibility suggests, of course, respective mechanic elasticity properties of at least one of the protofields (it is easy to see that it is mainly the e/m protofield, which gives rise to explicitly observed structures). However, mass production of field-particles in the system of coupled protofields should take place in a wide range of their attraction parameters, except for unlikely extreme cases of too strong attraction, leading to the protofield one-way collapse or disruption, and too weak attraction, which cannot produce massive particles (this latter case is actually realised in the space between the produced massive particles, where quantum beat is not possible any more because of the increased protofield tension, so that their attraction is realised only in the form of small, massless perturbations like photons). In that way one automatically gets the *self-tuning*, dynamically evolving cosmological structure of the Universe, naturally solving all “difficult” (and growing) problems of usual cosmology [10-13,17-20,24] (see also below).

The dynamically multivalued process of *any* unreduced interaction in the form of permanent chaotic realisation change gives rise to emergence of universally defined and physically real *space* (structure) and *time* (structure evolution), with their now rigorously derived observed properties. The above quantum beat process at the first level of structure formation in the initially homogeneous system of coupled protofields is respectively the source of the emerging lowest level of “enclosing”, fundamental space and “universal” time imitated by the corresponding postulated and abstract entities of unitary theory and “Newtonian” science. Specifically, the above highly *inhomogeneous* local squeeze of interacting protofields gives rise to the fundamental, *dynamically discrete* and “tangible”, material structure of physical space “woven” from two *dynamically entangled* protofields (as described above). In its turn, the inevitable *change* of centres of this squeeze (i. e. of *plural* and mutually *incompatible* system realisations) in *dynamically random* order provides the well-specified origin of *real, permanently flowing* (unstoppable realisation change) and *irreversible* (random realisation emergence order) *time*.

In rigorous expression, the dynamically determined *size* r_0 of a *physical point* of emerging real space is given by the characteristic distance between the neighbouring eigenvalues of the effective existence equation (4)-(5) within one realisation, $r_0 = \Delta x_i = \Delta_i \eta_i^r$, while the *elementary length* $\Delta x = \lambda$ of the same complexity level (the minimum distance between two points) is determined by the eigenvalue separation between different (neighbouring) realisations, $\Delta x = \lambda = \Delta x_r = \Delta_r \eta_r^i$. The *elementary time interval* Δt is naturally determined as the *quantum beat period* τ of the (major) elementary particle, $\Delta t = \tau = 1/\nu$, where ν is the quantum beat frequency, expressing the *intensity* of the process of *spatially chaotic realisation change*. The value of Δt can be obtained from the elementary length λ , determined above through the solutions of the EP formalism equations (4)-(5), and the velocity ν_0 of perturbation propagation in the e/m protofield (coupled to the gravitational protofield), $\tau = \lambda/\nu_0$, where ν_0 in this general expression is naturally identified at this (lowest) complexity level as the *speed of light* c , $\tau = \lambda/c$, because e/m protofield excitations are observed as photons. We thus obtain the well-defined origin of physically real space and irreversibly flowing time in the form of the same complex-dynamical quantum beat process, which determines the elementary field-particle structure [10-12,17-20,23,24].

Since physically real space and time are created in the process of permanent change of system realisations, while dynamic complexity is de-

terminated by the realisation number or the rate of their change, the main *integral measure of universal dynamic complexity* is given by the simplest linear combination of these dynamically emerging elements of space and time, i. e. *action-complexity* \mathcal{A} , essentially extending the meaning and applicability of usual mechanical action, which now expresses actually the number of realisations consecutively taken by the system and its discrete increment [10-12,17-20,23,24]:

$$\Delta\mathcal{A} = p\Delta x - E\Delta t, \quad (11)$$

where the coefficients p and E are recognised as (generalised) *momentum* and *energy* interpreted now as *universal differential complexity measures* (determined by spatial and temporal rates of realisation change):

$$p = \left. \frac{\Delta\mathcal{A}}{\Delta x} \right|_{t=\text{const}} \simeq \frac{\mathcal{A}_0}{\lambda}, \quad (12)$$

$$E = - \left. \frac{\Delta\mathcal{A}}{\Delta t} \right|_{x=\text{const}} \simeq \frac{\mathcal{A}_0}{\tau}, \quad (13)$$

with x and p understood in general as vectors, and \mathcal{A}_0 expressing the magnitude of characteristic action value.

It is easy to see that at the considered lowest complexity sublevels the smallest (and here the only possible) change and characteristic magnitude of action-complexity is given by the *Planck constant* h , $\Delta\mathcal{A} = \mathcal{A}_0 = h$, which reveals its genuine, *dynamical origin* as the fundamental *quantum of action-complexity* and explains its *final value* (due to realisation discreteness) and *universality* at those *lowest* complexity sublevels [10,12,15,17-20,23,24]:

$$E = - \left. \frac{\Delta\mathcal{A}}{\Delta t} \right|_{x=\text{const}} = \frac{h}{\tau} = h\nu. \quad (14)$$

The system state of rest ($p = 0$) is rigorously defined now as the *state with the lowest dynamic complexity* (of the quantum beat process for the elementary particle), for which equation (14) gives the following expression for the rest energy E_0 :

$$E_0 = \frac{h}{\tau_0} = h\nu_0, \quad (15)$$

coinciding with the famous de Broglie's suggestion [30-33], which leads to the idea of wave-particle duality and the expression for the particle

wave length, but now with the clearly defined origin of the “periodic phenomenon” within the elementary field-particle (quantum beat) and the related duality, which constitute the particle nature itself.

Since the rest energy E_0 in (15) is the (differential) complexity measure for the *spatially chaotic* cycles of contraction and extension of proto-fields in quantum beat, the latter can be described as *random walk* of the “flickering” squeezed particle state, or *virtual soliton*, within its (physically real) wavefunction, which gives rise to the property of inertia, in agreement with de Broglie’s “hidden thermodynamics” concept [34-37]. The inertia of a particle (and any object) is thus due to its (hidden) *internal multivalued (chaotic) dynamics*, where an attempt of partial ordering of the latter into a global motion state meets with final “resistance” of this already existing dynamics of the “hidden thermostat” trying to preserve the “temperature” of its internal (chaotic) motion. In view of special importance of the universal origin of mass in the context of this paper, we do not immediately introduce the quantitative mass definition measuring the described inertia effect and will try instead to consistently derive its magnitude from the rigorous analysis of global motion dynamics.

We restart from the mathematically rigorous and universal definition of the *state of rest* of any (isolated) system as the state with the lowest (always positive) value of system’s energy-complexity E (given by (13)) and the *state of (any global) motion* as, correspondingly, a system state with the value of its energy-complexity exceeding the minimum value of the state of rest [10,12,17-19,24]. The state of rest is characterised by the most homogeneous distribution of the dynamical realisation probabilities (7) (it is totally homogeneous for the isolated field-particle in the state of rest), which corresponds to the limiting regime of *uniform chaos* of complex dynamics, whereas a state of motion is realised as a less uniform realisation probability distribution within a regime of partially ordered, *self-organised* complex dynamics, where the generalised direction (probabilistic tendency) of this global motion is determined by higher values of corresponding realisation probabilities. It means that the action-complexity \mathcal{A} of the elementary particle at rest does not contain any spatial dependence and acquires such dependence on the (dynamically emerging) space coordinate x for the moving particle, $\mathcal{A} = \mathcal{A}(x, t)$, so that

$$\frac{\Delta \mathcal{A}}{\Delta t} = \frac{\Delta \mathcal{A}}{\Delta t} \Big|_{x=\text{const}} + \frac{\Delta \mathcal{A}}{\Delta x} \Big|_{t=\text{const}} \frac{\Delta x}{\Delta t} = p\nu - E,$$

or

$$E = -\frac{\Delta\mathcal{A}}{\Delta t} + p\nu = \frac{h}{T} + \frac{h}{\lambda}\nu = hN + p\nu , \quad (16)$$

where the total energy E of the moving field-particle is given by (14), the momentum p of its (global) motion, universally defined by (12), is now specified as

$$p = \frac{\Delta\mathcal{A}}{\Delta x}\Big|_{t=\text{const}} = \frac{h}{\lambda} , \quad (17)$$

ν is the global motion velocity,

$$\nu = \frac{\Delta x}{\Delta t} = \frac{\Lambda}{T} , \quad (18)$$

$\tau = \Delta t\Big|_{x=\text{const}}$ is the period of quantum beat (realisation change) measured at a fixed space point, $\lambda = \Delta x\Big|_{t=\text{const}}$ is the size of emerging spatial inhomogeneity of the average, global part of the moving system structure measured at a fixed time moment, and $\Delta t = T$ and $\Delta x = \Lambda$ are the “total” values of the quantum beat period ($N = 1/T$ is the respective frequency) and spatial inhomogeneity [10,12,17-19,24].

The complex-dynamical partition of the total energy in (16) and the accompanying expression (17) for the global motion momentum provide the new, causally complete understanding of unreduced dynamical structure of (any) motion. This structure contains the tendency of global, externally regular (though internally chaotic) system motion, described by the second summand, $p\nu$, in the total energy partition (16). Its first summand, hN , characterises the complementary tendency of totally random deviations of the system from the global motion (in our case, the former is the tendency of random walk of the virtual soliton of elementary particle). Moreover, expression (17) describes the emergence of spatial structure with the characteristic length λ in the global motion tendency, which in our case is easily recognised as the particle’s *de Broglie wave* with the wavelength $\lambda = \lambda_B = h/p$. Therefore, now there is nothing mysterious in this *dynamically emerging* phenomenon of *wave-particle duality*, which is but a natural manifestation of the universal complex-dynamical process of structure formation in the global system motion (maintained by system jumps between realisations). It is important also that despite external regularity, the global motion tendency appears and persists as *on average* more frequent, but individually *chaotic* system jumps between its realisations (here represented by the virtual soliton) “along” thus emerging spatial structure profile (the undular shape of interacting protofields in our case).

We have here the direct relation to the above property of inertia, since the process of dynamically multivalued interaction (here of protofields) “resisting” to the externally imposed tendency of global motion develops the global “undular deformation” proportional to its complex-dynamical inertia and performs that global motion in the form of “caterpillar motion”. As the (dynamically multivalued) system cannot avoid chaotic inertial deviations from the tendency of its global motion, the velocity v of the latter will always be less than the speed of any individual jump between realisations occurring at the velocity of perturbation propagation in the material of interacting components, $v_0 = c$, where the speed of light c , as well as the corresponding “relativistic” limitation $v < c$, is introduced in a physically causal way for the considered system of coupled e/m and gravitational protofields [13,14,17-19,24].

In order to obtain the quantitative relation between v and c in this picture, we note that during the time period of one jump within the global motion tendency, $\tau_1 = \lambda/c$, the system (virtual soliton) should perform $n_1 = c/v$ jumps of purely random deviations from the global tendency of duration τ each (where τ is defined according to (14)). Hence $\tau_1 = n_1\tau$, or $\lambda = V_{ph}\tau$, where $V_{ph} = c^2/v$ is the fictitious, superluminal “phase velocity” of matter wave propagation, appearing in the original derivation of the idea and the length value of de Broglie wave [33], which does not take into account the chaotic, multivalued part of particle’s dynamics. It remains only to insert the definitions of τ and λ , (14) and (17), in the obtained relation and we get the famous *relativistic dispersion relation*:

$$p = E \frac{v}{c^2} = mv, \quad (19)$$

which, contrary to usual relativity, provides the desired *rigorously derived* definition of *inertial mass-energy-complexity*, $m = E/c^2$ [13,14,17-19,24].

We can return now to the state of rest, where $E_0 = m_0c^2$ and m_0 is the *dynamically determined rest mass* of the quantum beat process, so that the key relation (15) postulated by de Broglie [30-33] takes its complete form:

$$E_0 = m_0c^2 = hv_0. \quad (15')$$

The dynamically determined *inertial mass-energy for the state of motion* is obtained in the same way from (14) as the frequency of *spatially chaotic* (though partially ordered on average) quantum beat:

$$E = mc^2 = hv = \frac{h}{\tau}. \quad (14')$$

Even though our complex-dynamical mass definition is not yet complete (we further specify it below), already at this stage we can state the rigorously substantiated absence or solution of the fundamental problems [9] of the conventional mass concept of the Standard Model, based on the existence and influence of the Higgs field. In particular, one may emphasize the *universality* of the obtained mass-energy definition (for arbitrary systems and complexity levels) as temporal rate of the (spatially) *chaotic* realisation change for all interaction processes involved, in their unreduced, dynamically multivalued version, eqs. (11)-(19). Therefore, inertia and (in general relativistic) mass-energy of a system is a major manifestation and (differential) measure of unreduced dynamic complexity of all system interactions (where certain, usually lower, complexity levels can eventually be excluded, if they definitely do not contribute to particular observations, for example, in nonrelativistic mechanics).

In close connection with these fundamental properties of the universally defined mass is the “evident” (actually postulated in usual theory), but now *rigorously derived* relation (19), $p = mv$, which is equivalent to *Newton’s laws of motion*, now not only postulated, but mathematically derived in their genuine, complex-dynamical meaning and causally relativistic content (totally lost in the usual version). Newton’s second law (in its generalised version) is obtained by time differentiation (in general discrete) of this relation, with now causally complete physical meaning of mass, energy, momentum, space, and time in terms of complex (multivalued) dynamics of all underlying interaction processes (starting from the lowest level of coupled protofields). This degree of rigour is unattainable for the Higgs mechanism and other nondynamical mass-origin hypotheses based on external influences of introduced additional entities.

Inserting now the fundamental relation (19) into the causal definition of the particle wavelength (17), we get the familiar, but now causally complete expression for the de Broglie wavelength in the physically real version of wave-particle duality in the form of dynamically multivalued quantum beat process:

$$\lambda = \lambda_B = \frac{h}{mv} . \quad (20)$$

For the particle in the state of rest we can further obtain the length of a jump of its virtual soliton (performed with the speed c), if we take into account that the quantum beat frequency $\nu_0 = m_0 c^2 / h$ from (15') corresponds to the wavelength

$$\lambda_0 = \frac{c}{\nu_0} = \frac{h}{m_0 c}, \quad (21)$$

which could be obtained from expression (20) for the de Broglie wavelength with the physically incorrect, but logically understandable parameter values $m = m_0$, $\nu = c$. For the electron with the rest mass $m_0 = m_e$ the length λ_0 of the virtual soliton jump between two “corpuscular” (squeezed) realisations of quantum beat coincides with the Compton wavelength λ_C , which provides its new interpretation in terms of complex electron dynamics (see also below):

$$\lambda_C = \frac{h}{m_e c}. \quad (21)$$

Due to the fundamental relation (14) between mass-energy and time, the complex-dynamical dispersion relation (19) specifies also the relativity of time flow. Substituting (19) in the energy partition equation (16) and using (14), we obtain the *causally substantiated* expression of *relativistic time dilation* as the relation between the externally and internally measured time periods (of quantum beat) τ and T for a moving particle:

$$\tau = T \left(1 - \frac{v^2}{c^2} \right). \quad (22)$$

We clearly see here the *physically real, complex-dynamical origin* of relativistic time dilation (as opposed to formal postulates of standard relativity) [10,12-14,17-19,24]. Since one and the same complex-dynamical process of quantum beat gives rise to both “swing of the pendulum” of the physically real clock, determining the fundamental time flow (purely random dynamical tendency of the first summand in (16)), and the global particle motion (externally regular tendency of the second summand in (16)), that internal system clock will slow down with the growing global motion velocity v , $T > \tau$, as the ever greater part of the total energy will pass from the first tendency (internal clock) to the second one (global motion). Due to the universality of our concepts of time, mass-energy, and motion, this result does not depend on the size and mechanism of any real time-measuring device (thus solving yet another “puzzle” of usual relativity).

In order to obtain the standard, directly measurable expression of this causally substantiated relativistic time dilation we use an additional relation between T , τ and the quantum beat period in the rest frame τ_0 or between the corresponding frequencies N , ν and ν_0 :

$$Nv = (v_0)^2, \quad T\tau = (\tau_0)^2. \quad (23)$$

This relation describes the physically transparent manifestation of conservation of the system realisation number expressed by frequencies, which is a version of the universal complexity conservation law [10,12-14,17-19, 24]. Eliminating not directly measurable τ from (22) with the help of (23), we get a familiar expression of time dilation, but where now both time itself and its relativistic dilation (relation to motion) acquire the physically real and universal origin:

$$T = \frac{\tau_0}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad N = v_0 \sqrt{1 - \frac{v^2}{c^2}}. \quad (24)$$

Using this expression of causal time dilation, together with (19) and (15), in equation (16), we arrive at the *causally substantiated* expression of *relativistic mass increase*:

$$m = \frac{E}{c^2} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}. \quad (25)$$

This relation provides further extension of complex-dynamical mass concept emphasizing the fact that *any* global, even externally regular motion emerges only as partially ordered tendency in the process of *dynamically random* jumps between system realisations, where each jump even within this “self-organised” global tendency occurs in the causally unpredictable, dynamically probabilistic way (with somewhat greater probability of falling into this tendency), thus contributing to the total system mass.

We can now consider other properties emerging within the same process of unreduced interaction of the two protofields and completing the self-consistent picture of particle properties and behaviour. We start with the explanation of the observed number of spatial dimensions, $N_{\text{dim}} = 3$, as the global realisation number for the interacting protofield system equal to the number of interacting entities (see the discussion after eq. (6)), the two protofields plus the coupling interaction. In a general case, the universe emerging from n protofields coupled by m (global) interactions should have $N_{\text{dim}} = n + m$ global spatial dimensions, which clearly implies that each additional fundamental entity (such as omnipresent interacting field) gives rise to additional spatial dimension(s) (this conclusion remains valid for any detailed dependence of N_{dim} on n and m). It is important that our

physically real space appears as tangible complex-dynamical entanglement of interacting entities, where the observed similarity of individual spatial dimensions (or “coordinates”) suggests equally globally uniform and direct mixture of interacting components, excluding any persisting special, separated status for some of them (as it is the case for the Higgs field in standard theory).

This protofield interaction process with N_{dim} global realisations (spatial dimensions) is further split, as we have seen, into the hierarchy of local realisations, starting from massive particles represented by the dynamically multivalued quantum beat processes, which form the observed ordinary, “heavy” *matter* (we obtain thus its rigorous physical and mathematical definition absent in usual theory). The quantum beat process within each massive particle produces (propagating) deformations in the surrounding material of each protofield, which change its properties and thus give rise to (maximum) *mn fundamental long-range interaction forces* of n different types between field-particles (where each interaction type is transmitted through its own “source” protofield). For our simplest case of two protofields with the single coupling, we obtain two (actually observed) fundamental long-range forces of different types, the electromagnetic and gravitational ones, which explains both their true origin and the accepted names, number and roles of the initial protofields.

We obtain also n short-range fundamental forces originating in the direct local interaction between (usually indistinguishable) elementary components of respective protofields. Indeed, we observe exactly two short-range forces for our universe ($n = 2$), where “weak” interaction is naturally associated with the direct interaction between neighbouring e/m protofield components (providing the real physical origin of the standard formal “electroweak symmetry”, now naturally “broken” from the outset), whereas “strong” forces originate from the direct interaction between gravitational protofield elements (which provides the interesting new connection between gravitational and strong interactions originating from the same, gravitational protofield, similar to “electroweak symmetry” for the e/m protofield, see also below). Moreover, since the basic source of strong interaction is related to practically irresolvable quarks, it is not difficult to conclude that the gravitational protofield can be described physically as a dense quark condensate, where an “individual” quark may in reality either not exist as such (appearing only in interaction processes) or be represented by an ephemeral and chaotically varying quantum beat mode of a deeper complexity level. This picture is supported also by recent experiments

on high-energy heavy nuclei collisions [38], where the expected “quark-gluon plasma” showed the dense liquid kind of behaviour, instead of that of a “gas” from the Standard Model prediction related to its interpretation of quark confinement (which also acquires a qualitatively new, physically real and consistent explanation in our picture).

One should add here that real-world structures are definitely asymmetrically displaced to the side of much lighter and deformable/elastic e/m protofield, which explains the essentially electromagnetic world dynamics and relative weakness of its gravitational interactions (see also below).

It is important that in this causally emerging structure of particles, fields and their interactions with the observed properties, the fundamental interaction forces appear from the beginning in their *naturally quantised* and *dynamically unified* version [10,12,13,17-20,24], due to their common source in the form of quantum beat. All four fundamental interaction forces are unified in the process of quantum beat (especially in its maximum squeeze phase of virtual soliton for heavier, hadronic particles), whereas their dynamically discrete, intrinsically quantum structure is due to quantum beat cycles.

In the case of e/m interaction this quantum structure is realised as the exchange of physically real photons (as opposed to canonical “virtual” photons), which emerge as weak, quasi-linear and therefore massless e/m protofield deformations. Note that this physically transparent origin of photons in our description, by contrast to the abstract “gauge symmetry” in the Standard Model that must then be “spontaneously” broken under the influence of specially introduced Higgs field, only confirms the redundant and contradictory nature of the latter related exclusively to the specific character and unitary limits of abstract approach of usual field theory, its “fundamental”, but finally “broken” and thus illusive symmetries (as opposed to our unbroken *universal symmetry of complexity*, unifying all real structures and laws [10,17-20,23-27]).

In the case of gravity, the high density and strong interactions within the gravitational protofield are incompatible with real (quasi-stable) “graviton” propagation, so that gravity is transmitted by quantised protofield density variation, which quickly lose their individuality with distance (it explains the absence of gravitational repulsion and conventional gravitational waves). It is also evident that both the e/m and gravitational interactions naturally obey the law of inverse square decrease with distance, just because of existence of exactly three spatial dimensions (now causally explained), up to possible small dissipativity of the gravitational protofield.

The causally defined and intrinsically unified connection between the number of initial fundamental entities (such as our protofields), the number of emerging spatial dimensions and the number of fundamental interaction forces between particles implies that any additional entity, such as the omnipresent Higgs field, should give rise to greater numbers of forces and dimensions, in contravention of observations, which totally confirm our minimum possible number of primordial entities. One could assume that the Higgs fields in reality plays the role of protofield coupling in our picture, but such interpretation contradicts both the nature of protofield (and any fundamental) interaction, occurring eventually due to separation of previously united entities, and the properties of the Higgs field consisting of already massive particles that interact with other, also already existing elementary particles, etc. Therefore any additional entity would be definitely redundant in our (causally complete) description at this stage and can be considered only in the case of explicit necessity, in order to describe the observed properties that (provably) cannot be described in the obtained picture.

It is very important that the proposed concept of complex-dynamical mass emerging in the system of two interacting protofields includes the *naturally unified* (or “equivalent”) *inertial and gravitational aspects (and manifestations) of mass*, thus avoiding from the beginning the glaring absence of any gravitational aspect in the Higgs model. According to the above general picture, gravitational interaction between particles (and thus any bodies) is transmitted through the gravitational protofield, locally deformed by respective quantum beat processes, and is therefore proportional to the quantum beat frequency or (relativistic) inertial mass (in direct relation to the *intrinsically quantum* origin of gravity in our description). The gravitational protofield density, determining the local quantum beat frequency, becomes inhomogeneous in the presence of massive bodies (i. e. other quantum beat processes), so that instead of eq. (14') we get:

$$M(x)c^2 = hv(x) = mc^2\sqrt{g_{00}(x)}, \quad (26)$$

where $v(x)$ is the local quantum beat frequency of a test particle, $M(x)$ is its total mass, m its relativistic mass in the absence of gravitational field (i. e. other bodies), and conventional “metric” $g_{00}(x) < 1$ describes in reality the local distribution of gravitational protofield tension. For weak fields $g_{00}(x) = 1 + 2\varphi_g(x)/c^2$, where $\varphi_g(x) < 0$ is the gravitational field potential [39]. Since $v(x)$ determines the local rate of now causally defined time flow, we obtain, as follows from (26), the real physical origin of (causally

derived) effect of time dilation in gravitational field [10,12,14,17-19,24], instead of formal postulates about “deformed” geometric “mixture” of abstract space and time variables.

In that way, our complex-dynamical mass concept includes the effects of not only special relativity and gravitation, but also of general relativity, now in the *causal and naturally quantised* version. The *equivalence* of inertial and gravitational mass properties is an integral part of this complex quantum beat dynamics. That unification degree goes far beyond the bounds of the Standard Model. In particular, complex-dynamical quantisation of gravity in our description does not need the introduction of additional “graviton” field and the related tricky formal constructions of usual theory, whereas the existence of real gravitons in the form of long-living micro-excitations of gravitational protofield (quark condensate), as well as of classical gravitational waves in the opposite macroscopic limit, seems improbable because of the high dissipativity of dense and strongly interacting quark condensate (see above), by contrast to photon analogues in the light and elastic e/m protofield (the physically transparent difference escaping the simplified abstract approach of usual theory).

The same complex-dynamical construction of two interacting protofields giving rise to the observed diversity of field-particles and their now unified interaction forces includes also the natural explanation of elementary particle spectrum and in particular the famous “hierarchy problem” expressing the huge difference of 17 orders between the largest values of particle masses (within their quite sufficient diversity), falling within the electroweak energy scale of 100 GeV, and the conventional Planck mass unit (10^{19} GeV). In our complex-dynamical mass interpretation it becomes evident [10,13,17,19,24] that this huge difference of the highest observed particle masses from the Planck mass is related to the incorrect use of the constant γ of *long-range* (Newtonian) gravitational interaction in the formal dimensional expressions for Planck units, which correspond in reality to the *short-range* interaction scale within the virtual soliton, i. e. the maximum squeeze state of the coupled protofields in the process of quantum beat.

The ordinary, long-range gravitational constant γ describe physically indeed very “long” and indirect way of gravity transmission from the quantum beat processes of one interaction participant (massive body) to the corresponding local changes in the gravitational protofield matrix, then through the gravitational protofield to the location of another interaction participant, and finally to the e/m protofield (quantum beat) in that loca-

tion. All those links are effectively weak because of their “induced” and “indirect” character (also due to the above world structure “displacement” from the effectively hidden and only weakly interacting gravitational protofield to the directly perceived interface of e/m protofield), which explains also the well-known weakness of gravity with respect to e/m interaction (thus providing additional confirmation of our picture).

By contrast, the short-range processes, determining the formation of (the heaviest) virtual solitons, include practically direct and strongly localised protofield interactions, where the usual γ value for the long-range and weak interaction should be replaced by the effective value for the short-range and strong interaction $\gamma_0 \gg \gamma$, which can be derived just from that huge difference between the really observed, $m_{\text{exp}}c^2 \approx 10^2 \text{ GeV}$, and traditional, $m_p c^2 \approx 10^{19} \text{ GeV}$, values of the Planck mass: $\gamma_0 = (m_p/m_{\text{exp}})^2 \gamma \approx \approx 10^{34} \gamma$. Note that we actually deal here with the “gravi-strong symmetry” mentioned above and unifying gravity with strong interaction by their common media of origin, the gravitational protofield (but actually the mass-energy scale $m_{\text{exp}}c^2$ within the heaviest virtual solitons realises the natural dynamic unification of all four fundamental interactions, as a manifestation of the universal symmetry of complexity).

All the really observed extremal values of mass and other particle parameters obtain thus their causal and realistic explanation, without introduction of redundant particle species or “hidden dimensions” [40,41] and in full agreement with the obvious sufficiency of the observed particle spectrum [10,13,17,19,24]. It follows that the actually senseless traditional values of Planck units (or respective, even more fundamental “natural units” of measurement) should be excluded from numerous fundamental constructions of usual theory (for example, in quantum gravitation and cosmology), which implies their essential modification.

One more, independent confirmation of the value of the order of 100 GeV for the real Planck mass (determining the amplitude of nondestructive protofield interaction) is provided by its proximity to largest (meta) stable nuclei masses, since the atomic nucleus with strongly coupled components can be considered as a unified complex-dynamic quark agglomerate resembling a huge hadronic “elementary particle”. The mass of any such compact hadronic object, in the form of either elementary particle or atomic nucleus, can hardly exceed m_{exp} , since it would need local protofield interaction amplitude exceeding the binding energy of at least the e/m (and probably gravitational) protofield, which provides the causal interpretation of the (electro-) weak energy scale, $m_{\text{exp}}c^2 \approx 10^2 \text{ GeV}$.

In addition to mass, *other intrinsic properties* of elementary particles obtain their causally complete explanation within the *same*, unified picture of complex-dynamical particle structure [9-24]. Thus, *electric charge* is but another measure of the same quantum beat complexity, in accord with the standard connection between the elementary charge e and Planck's constant h (now understood as the action-complexity quantum, see above): $e^2 = \alpha \hbar$ (where α is the fine-structure constant and $\hbar = h/2\pi$). This explains *universal* (now *dynamical*) electric charge *quantisation* in units of e similar to action-complexity quantisation in units of h , but now emphasizing the properties of e/m interaction of elementary quantum beat processes related to their temporal (periodic), rather than spatial (chaotic) behaviour (as in the case of mass). Unified time flow in the universe implies *phase synchronisation* of all elementary quantum beat processes *up to phase inversion*, which explains the existence of *two and only two* opposite kinds of electric charge (with the opposite phases of quantum beat processes) having the observed properties of their interactions [10,12,13,17-19,24].

Another essential internal property of elementary particles, their *spin*, also emerges dynamically, in the form of inevitable, highly nonlinear vorticity of the e/m protofield dynamically squeezed to its corpuscular state of virtual soliton [10,12,13,17-19,24]. Because of the shear instability in the protofield material, such highly nonuniform squeeze cannot practically occur in straight lines and will induce the spiral, spinning protofield motion around each reduction centre. The quantum beat rest energy (15) can now be presented in another form reflecting this internal spin dynamics: $E_0 = \hbar \omega_0 = \hbar v_0/2 + s \omega_0$, where $\omega_0 = 2\pi \nu_0$ is the quantum beat circular frequency, while $s = \hbar/2$ is the observed angular momentum of elementary spin (for the simplest fermion case). This expression's summands, $\hbar v_0/2$ and $s \omega_0$, can be considered as quantum beat energy parts corresponding to its (inseparably related) "oscillation" and "spin" components. In addition to the origin and quantised value of spin, we obtain here the causal origin of *magnetic field* (in the extension phase of the same spin vortex), in conformity with the laws of electrodynamics [10].

Another relation involving the complex-dynamical mass origin emerges as an additional causal interpretation of the fine-structure and Planck constants, if we rewrite the mentioned standard relation between e , α and h in a new form:

$$E_e = m_e c^2 = \frac{2\pi}{\alpha} \frac{e^2}{\lambda_C} = N_{\text{sr}}^e \frac{e^2}{\tilde{\lambda}_C}, \quad \lambda_C = \frac{h}{m_e c}, \quad N_{\text{sr}}^e = \frac{1}{\alpha}, \quad \tilde{\lambda}_C = \frac{\lambda_C}{2\pi}, \quad (27)$$

where m_e is the electron rest mass and λ_C the Compton wavelength (see (21')). It follows that $N_{\text{gr}}^e = 1/\alpha$ ($=137$) gives the *number of electron's realisations* and $\tilde{\lambda}_C = \lambda_C/2\pi$ ($\approx 3.9 \times 10^{-11}$ cm) the *length of elementary electron jump* between realisations (both quantities defined up to a numerical coefficient of the order of π) [10,12,17,19,20,24], with the latter being also in agreement with the previous description in (21), (21'). According to the universal interpretation of this jump length (see above, before eq. (11)), the Compton wavelength is the dynamically emerging elementary length of this complexity level, $\lambda_C = \Delta x_r = \Delta_r \eta_i^r$. Note also the interesting coincidence between the thus interpreted *fine-structure constant* $\alpha = 1/N_{\text{gr}}^e$ and the *electron realisation probability* α_r given by the universal expression (17) for the dynamic probability.

Further details of the complex-dynamical causal origin of fundamental constants are obtained from yet another form of the same e - \hbar relation:

$$\hbar = N_{\text{gr}}^e \frac{e^2}{c} = \tilde{\lambda}_C p_e, \quad \tilde{\lambda}_C = N_{\text{gr}}^e r_e, \quad (28)$$

where $p_e = m_e c = E_e/c$ and $r_e = e^2/m_e c^2$ ($\approx 2.8 \times 10^{-13}$ cm) is the ordinary "classical radius" of the electron. Since the quantum beat process of every particle is a (compound) realisation of the interacting protofield EP (4)-(5), the first relation of eq. (28) shows that N_{gr}^e and $\tilde{\lambda}_C$ can be interpreted as the EP potential well width, e^2/c and p_0 as its corresponding depth, and \hbar as its "volume". Whereas the EP well width and depth are different for different particle species, their product, or the EP well volume, is a universal quantity (Planck's constant) characterising the balance between the protofield interaction force and their deformation properties (and expressed, without any coincidence, in units of action-complexity). This reveals the *ultimate causal origin of the Planck constant* \hbar , as well as of its *absolute universality* at the lowest complexity levels, including various particle agglomerates, such as atomic nuclei [17,19,20,24]. Relatively wide and shallow realisations of the interacting protofield EP, such as the one for the electron in eq. (28), correspond to light, leptonic particles with $N_{\text{gr}}^e \gg 1$ and $\alpha_r, \alpha \ll 1$ (for the respective interaction constants). In the opposite limiting case, the most deep and narrow EP realisations with $N_{\text{gr}}, \alpha_r \sim 1$ correspond to the heaviest hadronic particles and their agglomerates. The entire diversity of the observed particle spectrum and their dense agglomerates is situated between those two limiting cases, preserving the obtained general relations and causally interpreted universal constants.

The second expression of eq. (28) shows also that the EP well width λ_C contains exactly $N_{\mathfrak{R}}^e$ sizes r_e , whence one can deduce that each corpuscular realisation of virtual soliton for the electron has just that size r_e , so that the complete system (electron) realisation set just fills densely the accessible EP width. According to the above description, this localised realisation size determines the (finite) dimension of the real physical “point” of dynamically emerging space, $r_0 = \Delta x_i = \Delta_i \eta_i^r$, which thus coincides with the classical electron radius, $r_0 = r_e$ (up to a coefficient of the order of π), thus providing the new, deeper sense to that familiar quantity.

In summary, based on our central complex-dynamical interpretation of mass, we obtain the intrinsically unified and causally complete picture of particle properties, which includes the physical origin, structure and spectrum of elementary particles, their internal and dynamic properties unifying quantum and relativistic behaviour as different, but now totally causal, physically transparent manifestations of the same complex-dynamical protofield interaction process, the dynamically unified particle interaction forces with their observed properties, as well as the transparent and unified dynamic interpretation of fundamental constants c , h , α , e , and γ (including the explanation of their universality and relations), which permits one to solve multiple stagnating mysteries and contradictions of usual theory, but without artificial introduction of abstract and in reality redundant entities, such as additional fields/particles, hidden dimensions and dark matter/energy (see also [10-24] for further details, including the *universal unbroken symmetry of complexity*, genuine quantum chaos, quantum measurement, classical behaviour emergence in closed microscopic systems, etc.). This strictly symmetric complex-dynamical world picture contains also *complex-dynamical* (dynamically multivalued) *cosmology* with self-tuning universe parameters, which naturally avoids or solves respective “standard” and “new” problems of usual, dynamically single-valued (unitary) cosmological models of zero dynamic complexity, including “dark” mass and energy, being in reality but artifacts of that unitary theory, related to its artificial limitations [19,20].

3. COMPLEX-DYNAMICAL HIGGSLESS ORIGIN OF MASS, ITS EFFECTS AND ADVANTAGES

The causal and consistent solutions of interconnected problems of fundamental physics demonstrated in the previous section provide solid support for the entire picture of unreduced complex interaction dynamics and its

purely dynamic mass concept showing the redundancy of specially introduced Higgs bosons and field from the standard theory, which involve a whole series of additional contradictions and “unsolvable” problems. In this section we systematise these advantages of our solution (generally already mentioned above) and consider further important conclusions for particle physics related to this solution (see also [19]).

(1) Already very general considerations show that the genuine, non-contradictory origin of such fundamental property as mass, with its observed features (on all levels of world dynamics), should have a *universal dynamical nature* based on *chaotic* behaviour with the intrinsically included unified, dynamically derived effects of *quantisation*, *relativity* and *gravity*. These demands are related either to the features of the property of mass (such as unified manifestations of its inertial and gravitational qualities) or to the same, “fundamental”, i. e. the lowest, level of origin of both particle mass and dynamics.

We have shown in the previous section how this unique combination of properties is directly obtained in our concept of mass from the quite general, rigorous and unreduced analysis of the underlying interaction process with the simplest possible starting configuration (two attracting protofields), without any postulated entities, laws and rules (on the contrary, all properties and laws are consistently derived from the *unified* analysis of the unreduced interaction process as corollaries of the *unbroken symmetry of complexity*).

By contrast, it is evident that these necessary qualities of the correct concept of mass are multiply and directly *violated in the Higgs field and bosons hypothesis*: the origin of mass there is neither universal nor dynamic, but is reduced instead to the additional material entity (inevitably leading also to other, actually absent observable features), without any role of “thermal”, chaotic dynamics and without links to other necessary properties (gravity, relativity, quantisation). In other words, such artificial introduction of additional entity for the explanation of (otherwise “inexplicable”) observed properties, so typical for usual, unitary theory, leads to the “bad”, technical complexity of the obtained contradictory construction because of rejection of “good”, real and dynamical complexity that just constitutes the natural, unified and sufficiently versatile explanation for all observed properties (both intrinsic and dynamic ones).

(2) Turning now to a more detailed description of these unified and universal (in our approach) qualities of mass and other particle properties, we start with the *inevitable existence of additional observed features* (forces, particles, dimensions) in the case of nondynamical origin of mass

due to interaction with the specially introduced, additional field (absent in our analysis). Indeed, as follows from our universal analysis of global interactions (see section 2, after eq. (25)), the number of observed spatial dimensions and particle interaction forces is determined by the number of global interacting fields. As we have seen, all the observed dimensions, interaction forces and their properties are just exactly described by the global interaction of two initial (and physically “unavoidable”) proto-fields, whereas the existence of any additional global entity, such as the Higgs field, would correspond to greater number of dimensions, interaction forces and elementary particles themselves, which deviates too much from observations. Inconsistency of the standard theory approach is in the fact that it postulates only one, “just needed” result of such global field existence (the mass of certain particles) while considering it as “neutral”, non-interacting entity in other aspects.

(3) The necessary *universality* of our intrinsic, dynamical mechanism of the appearance of mass is related to the universality of the dynamic multivaluedness of any real interaction processes giving rise to massive behaviour at the lowest but also all higher complexity levels. This universality is inevitably and totally absent in the standard theory, where the Higgs field appears initially as the necessary source of mass of the exotic W^\pm and Z bosons (transmitting weak interaction at very short distances), with the following “generalisation” of this feature to other particles, inevitably including other complicated and contradictory interactions, which finally involve other sources of mass, such as quark interactions and motion within hadrons (see e. g. [42,43]).

(4) It is important also that the universality of the origin and exact definition of mass (see eqs. (14), (14'), (15), (15')) in our approach applies not only to individual elementary particles as in the Higgs mechanism (which is not the main one already for compound elementary particles, such as hadrons), but persists also for *any compound and macroscopic systems*, at respective levels of complexity (multivaluedness) of their dynamics. This quality of mass is essential for the correct description of observed classical and relativistic dynamics with the direct involvement of (varying) mass.

(5) Related to this is the necessary fundamental (observed and omnipresent) quality of mass as the *universal measure of the “quantity of matter” (and the equivalent energy)*, which follows directly from our definition of mass (cited in the previous item) as the quantity of “hidden chaotic motion” (dynamically random choice of each next system realisation) and is not evident at all for the Higgs mechanism depending on magnitudes of very different interactions of arbitrary elementary mass carriers with the

Higgs field and between themselves. In particular, the fundamental and multiply confirmed energy/mass conservation law becomes in this case rather indefinite.

(6) This mass feature from the previous item is closely related to its source in the form of *dynamically random*, “stochastic” or “thermal” hidden motion, which can be *the only* noncontradictory explanation for the property of inertia, as it was noticed since a long time by the founders of modern physics and in particular was rather exactly specified in the famous (but practically unrecognised) concept of the “hidden thermodynamics of an isolated particle” by Louis de Broglie [34-37] (see also the previous section, after eq. (15)). By contrast, a source of mass depending on the direct, regular interaction with other entities (as in the Higgs mechanism and other mechanisms from the standard theory) explains poorly the property of inertia and will be subjected to too great fluctuations of such interactions, depending on the position and motion direction.

(7) In its turn, this chaotic, multivalued dynamics of quantum beat of elementary particles (and of realisation change of any system at higher complexity levels), which determines the concrete mass source in our theory, constitutes also the *physical essence and dynamical structure of particles themselves* (or more complex systems), for which mass is a major, *intrinsic* property. It is evident that this is also the necessary quality of the noncontradictory definition of mass, which is absent for the case of *extrinsic* Higgs mechanism (and other mechanisms from the standard theory) not related to the physical structure of particles remaining unclear in the Standard Model. Moreover, it appears, in the Higgs mechanism, that the Higgs bosons of this extrinsic mass source already possess mass themselves, which gives rise to further series of contradictions.

(8) The essential and fundamental quality of mass, naturally emerging in our mechanism of complex-dynamic protofield interaction, is the *gravitational aspect* of the same inertial mass, in accord with the *principle of equivalence*. In our theory it is related to the causal system of dynamically unified particle interactions including both naturally quantised gravity and the effects of general relativity. All of it, including gravitational manifestations of mass, is absent in the Standard Model, Higgs mechanism, and other versions of unitary theory, where gravity remains a force of “mysterious” physical origin only formally modelled in the geometric scheme of general relativity, escaping quantisation and qualitatively separated from other interactions and properties. Therefore, usual theory and its concept of mass do not provide any realistic perspectives of necessary unity and causality naturally present in our approach.

(9) We specially emphasize the already mentioned natural inclusion in our complex-dynamical mass concept of all *effects of special and general relativity* (eqs. (22)-(26)), which have now *causal (complex-) dynamical origin*, while they are only separately and formally postulated in standard theory, without any relation to the Higgs mechanism or other unitary sources of mass.

(10) The origin of mass proposed here includes the main features of the *observed particle mass spectrum* and in particular its observed limitation by the electro-weak border (of the order of 100 GeV), thus *solving the mass hierarchy problem* (section 2), which is absolutely beyond the results of the Higgs mechanism of the Standard Model, where the particle mass spectrum remains unexplained (as well as the physical origin of particles as such) and the hierarchy problem remains unsolved (together with other contradictions related to the standard, too extreme values of Planck units).

(11) Note finally the self-consistent *cosmological consequences* of the proposed complex-dynamical origin of particles, their mass and the whole universe, where the minimum initial interaction configuration, without any special postulates and a priori laws, provides causal solution to all old and new “unsolvable” problems of usual cosmology, including the latest paradoxes of dark mass and energy (which is possible, of course, due to the internal richness of the multivalued dynamics of unreduced interaction artificially reduced practically to zero in usual unitary models) [19,20]. In direct opposition to the intrinsic source of universe structure formation in such unreduced interaction dynamics, the unitary way of problem solution (in this case of the particle mass problem) by artificial addition of a new omnipresent substance (the Higgs field) leads inevitably to multiple additional difficulties of cosmological scale related to the global origin, interactions and dynamics of that additional substance, which enlarge the already long list of other “hard” problems of usual, unitary cosmology.

(12) Returning to the “*experimental confirmation*” of the *Higgs boson existence* [7,8] in the form of relatively weak, but noticeable peak in the spectra of high-energy proton interaction products, we should emphasize *another, much more comprehensive interpretation* of this scattering feature in the framework of our complex-dynamical protofield interaction [9].

It is not difficult to note the approximate coincidence between the energy position of the observed scattering resonance (125 GeV), interpreted in the standard theory as the mass of the rapidly decaying Higgs boson, and our protofield coupling magnitude inevitably coinciding with the renormalised Planck mass value, greatest masses of particles and their sta-

ble agglomerates (atomic nuclei), and the canonical “electro-weak (unification)” scale (section 2). Therefore, a much more consistent interpretation of the observed faint interaction resonance (if we rely on the complicated experimental-digital procedure of its registration) would relate it to the energy “rupture” point of the protofields and their coupling leading to the weak scattering singularity (due to the natural peak of various particle production that “fill the breach” in the broken protofields), but also explaining the limits on the mass spectrum of the observed particles and their dense agglomerates (taking into account, in particular, the gravitational protofield structure of quark condensate).

Such causally complete interpretation of these experimental results [7,8] is supported also by the observed complicated multi-peak structure of the energy spectra in the vicinity of “major” feature at 125 GeV, whose origin would be much less evident (it is actually ignored) in the case of Higgs boson formation, but on the contrary is a natural manifestation of complicated multicomponent interaction processes close to maximum interaction amplitude and protofield rupture deformation. Therefore, these experiments on the Large Hadron Collider actually registered not the mass of additional, redundant particle species, but rather the protofield coupling amplitude in our picture, which successfully confirms other, independent estimates for this value in our approach, thus increasing the general consistency of all its results.

To further unfold this system of theoretic-experimental correlations in our description, we note that the mentioned canonical energy of electro-weak (and there purely formal) interaction unification of the same order of 100 GeV is now interpreted much more realistically as the binding energy of the e/m protofield components, or its rupture energy, or the (limiting) amplitude of its coupling to the gravitational protofield within particles and other agglomerates, which is actually determined, in particular, in these experiments under the name of the “Higgs mass” (the latter provided with much less comprehensive and consistent interpretation). In that way, all the standard “electroweak unification” appears now in a quite new, causally complete sense as the physically real unification of short-range forces (of binding and repulsion) between the neighbouring e/m protofield elements and long-range electromagnetic forces of “deformative” origin in the same protofield represented by a real, elastic physical medium (of quasi-continuous structure in the last case).

Further development of this realistic interpretation (which is left for future work) implies respective causal extensions and essential modifica-

tions in interpretation of such (rather ephemeral) entities related to the same e/m protofield as the standard “vector bosons” W^\pm , Z and neutrinos. The latter could accept the role of certain excited states of the interacting protofield elements, whereas the “experimental observations” of W^\pm , Z bosons and their “mass” (of the same order of 100 GeV) can in reality reflect only the amplitude (or “maximum strength”) and certain symmetry of “weak” interactions between the e/m protofield elements, which is not eventually reduced to real and in addition massive particles (especially taking into account the universal complex-dynamical mass definition in our approach). Since the gravitational protofield is naturally identified with a quark condensate, the uniformly interacting with it e/m protofield can be interpreted as a state of “separated”, pseudo-free gluon field (medium), whose elements and their interactions originate in gluon combinations (which in their turn need further causal physical concretisation).

Moreover, analysing the universal “interactive” origin of elementary particles and their intrinsic properties in our approach, comprehensively confirmed, as we can see, by all experimental observations (as opposed to restricted unitary models of the standard theory), we can advance a tentative general statement that the existence of *any* fundamental, especially massive, *scalar field and boson* (such as the Higgs field and boson) is *impossible* in our world in principle (irrespective of their detailed role and origin). The importance of this conclusion is due to the fact that such fields often appear in various formal “models”, including the Higgs field theory. It is based on the fact that the same field interaction that leads to formation of related (massive) field-particles, should also give rise to their non-zero spin (section 2). One should certainly add here the above undeniable consideration that inevitable interactions of any such supplementary omnipresent field would lead to respective growth of the number of observable forces, particles and dimensions (section 2), whose absence renders the existence of such entity redundant and contradictory.

In summary, we come to a conclusion that certain informal universe structure “asymmetry”, where fermions play the role of the elements of the “main”, structure-forming matter, while *vector* bosons serve *only* for “transmission” of the necessary fermion interactions (and cannot really exist beyond that function), has fundamental and rigorous systemic basis and can hardly be “violated”, for example, by existence of any nonlocal scalar field or else “supersymmetry”, this yet another artificial and abstract construction, “mathematically convenient” for the unitary theory, but leading to growing numbers of redundant and unobserved entities.

4. NEW RESEARCH STRATEGY IN HIGH-ENERGY PHYSICS AND FUNDAMENTAL PHYSICS IN THE WHOLE

The results and conclusions of this paper in favour of Higgsless, complex-dynamical origin of mass, as well as all other intrinsic and dynamical particle properties (sections 2 and 3), imply not only essential changes in interpretation of existing old and new observations, but also deeply substantiated changes in the whole research strategy in high-energy physics, particle physics and fundamental physics in general. Whereas the currently dominating “positivistic” paradigm of these research fields is based on the development of ever more technically powerful empirical search with the following superficial (unitary) “ordering” of the discovered new structures and properties, the above causally complete analysis of unreduced, complex-dynamical interaction of simple “primordial” entities demonstrates the importance and efficiency of just that kind of deep understanding of the dynamically multivalued basis of the observed processes and structures. The traditional approach is oriented to the unlimited “horizontal” expansion (e. g. of new particle species and accelerator energy), while the complex-dynamical extension of usual understanding provides qualitative progress of “vertical” comprehension of the real depth of (micro-) world dynamics and consistently explains the (already covered experimentally) *finite* range of its “horizontal” structure (including the indispensable, really existing particle/field species and thus the energy ranges of existing experimental facilities). It means that the still dominating orientation to permanent, ever more expensive and technically over-complicated extension of energy and spatial limits of accelerators and other facilities (see e. g. [44,45]) should be replaced by *qualitatively new strategic goals* of detailed, causally complete investigation of complex (multivalued) dynamics of particles and their interactions within the already attained quantitative parameter ranges of high-energy facilities [9,17,23,24].

In particular, as follows from the comprehensive and self-consistent correlation system of theory and experiment in the framework of our analysis (sections 2 and 3), the mass-energy scale of “electro-weak unification”, 100 GeV, not incidentally coinciding with the highest masses from the more than sufficient system of already experimentally discovered elementary particles and their dense aggregates, as well as with the renormalised Planck mass unit, determines the upper limit of energies necessary for further studies with the help of high-energy facilities. The already attained energies of the order of 10 TeV of the last experiments provide the reserve

of two orders of magnitude with respect to the highest mass-energy values of real elementary particles, which is quite sufficient for the study of all possible details of these really existing elementary structures and interactions. Contrary to such theoretically (Occam's razor) and experimentally (resources) parsimonious strategy oriented to efficient, deep understanding, standard theory always asks for ever greater energy increase for unpredictable detection of its abstract, in reality redundant entities (particles, fields, dimensions) introduced as imitative replacement of incorrectly ignored and really existing dimensions of unreduced interaction dynamics.

Equally sharp distinctions between these two types of strategy characterise motivation, final purposes and applications of fundamental research. In the traditional approach, research in particle physics (as well as in fundamental physics in general) is motivated and progresses mainly under the influence of poorly defined empirical curiosity about "something new", which "probably" will be explained later and maybe will find practical application in the long run (hopes becoming ever more illusive). It has especially straightforward manifestations just in high-energy physics, where the well-known limitative "wisdom" of respective unitary theory, "shut up (with questions) and calculate" can be reformulated as "shut up (with understanding) and accelerate", implying that something (new) will probably be produced in those (ever more) accelerated particle collisions. The illusive efficiency of such strategy at the time of massive new particle discoveries tends to zero today, just because of the finite range of objectively sufficient set of elementary entities.

In our qualitatively different approach, based on the causally complete analysis of the underlying complex-dynamical interaction processes, the universal and rigorously defined dynamic complexity itself, its unbroken symmetry and causally derived laws for physically real (rather than abstract) entities constitute the unified, reliable guiding principle for both fundamental research and expected applications, which are performed now not in the traditional blind empirical fashion. In particular, as we have seen, such unreduced complex-dynamical analysis provides, first of all, solutions to all stagnating fundamental problems of usual, unitary science, including its characteristic supernatural "mysteries", followed by provably efficient applications (while one also avoids huge and objectively vain expenditures for futile experimental searches, which can also be considered as important practical application).

One of today's most important directions in applied fundamental physics is certainly the search of qualitatively new sources of "big" energy, in the situation of approaching exhaustion of its traditional fossil

sources. Based on our results, we can make the fundamentally substantiated conclusion that irrespective of the detailed physical mechanisms of operation of those new sources, from plasma physics to any subatomic transformations, their real, specific, and necessary basis will always be due to the unreduced complex dynamics of real multicomponent (and most probably multilevel) interactions. Correspondingly, modern difficulties in creation of new energy sources are due to the dominating unitary paradigm of the standard approach, which just “deliberately” and inevitably reduces the effective dynamic complexity of the studied processes, and with it the search efficiency, down to zero.

Therefore, the radical turn in research strategy of high-energy physics and deep matter transformation is indispensable, directed to causally complete understanding of occurring complex-dynamical interaction processes, in the framework of rigorously and universally defined dynamic complexity concept (absent in the unitary “science of complexity”) [9-24]. In addition to concrete fundamental and practical problem solution discussed above, it will provide the issue from the modern general state of stagnation in fundamental science leading to considerable and practically dangerous decrease of interest in scientific research in the whole, despite the fact that it is the only source of new progress, so necessary today (but possible now only at a superior level of unreduced complex dynamics).

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