COMPLEX-DYNAMIC ORIGIN OF QUANTISED RELATIVITY AND ITS MANIFESTATIONS AT HIGHER COMPLEXITY LEVELS

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Abstract

Unified and causal complex-dynamic origin of standard (special and general) relativistic and quantum effects revealed previously at the lowest levels of world interaction dynamics is explicitly generalised to all higher levels of unreduced interaction processes, thus additionally confirming the causally complete character of complex-dynamical, naturally quantised relativity, which does not contain any artificially added, abstract postulates. We demonstrate some elementary applications of this generalised quantum relativity at higher levels of complex brain and social interaction dynamics.

The fundamentally *emergent* character and dynamic origin of all observed entities and laws of their behaviour in the universal science of complexity [1-16] includes the *unified complex-dynamical* and totally *causal*, physically real origin of all “quantum” and “relativistic” properties of elementary particles and their agglomerates in larger bodies [1,3-6], in contrast to inexplicable “mysteries”, abstract “principles”, and related “paradoxes” of standard, unitary quantum theory and relativity, leading to their irreducible separation and unsolvable problems in applications. Whereas large and abrupt changes of dynamic complexity (e. g. of a particle) account for quantum leaps and other quantum phenomena, gradual and smooth evolution of the same dynamic complexity measures (like energy or momentum) in motion processes appear as “relativistic effects”, thus *dynamically* explained and *intrinsically unified* with quantum complexity manifestations by the underlying well-specified and *physically real* basis of *unreduced* interaction (in this case between two primordial protofields).

Universality of complex dynamics of unreduced interaction processes implies that major “quantum” (dynamically discrete and dualistic) behaviour features from the lowest complexity sublevels of elementary particles reemerge at all higher complexity levels (together with respective levels of physically real space and time), as confirmed by the universal Hamilton-Schrödinger formalism (and the underlying symmetry of complexity) applicable to any system dynamics and generalising all known (correct) dynamic equations, laws and principles [1-15]. It is natural to expect therefore that all “relativistic” manifestations of the same unreduced interaction complexity should also reappear at any higher complexity level [1,3,5], due to the same universal character of our initial protofield interaction analysis at the lowest complexity level.

In order to specify that generalised complex-dynamic relativity, we start, similar to the lowest interaction level analysis [1,3,5], with the emergent elements of space $\Delta x = \lambda$ (eigenvalue difference between neighbouring system realisations) and time $\Delta t = \tau$ (duration of transitions between realisations, or realisation change events) at arbitrary complexity level, related to the universally defined action-complexity $\mathcal{A}$, momentum $p = \partial\mathcal{A}/\partial x$ and total energy $E = -\partial\mathcal{A}/\partial t$:

$$\lambda = \frac{\mathcal{A}_0}{p} , \quad \tau = \frac{\mathcal{A}_0}{E} , \tag{1}$$

where $\mathcal{A}_0 \gg h$ is the characteristic action-complexity value (and change) at the considered complexity level, situated typically much higher than quantum sublevels with $\mathcal{A}_0 = h$ (where this unique value of $\mathcal{A}_0 = h$ is more exactly defined than $\mathcal{A}_0 \gg h$ at higher complexity levels). The basic realisation change process can be described also as the "generalised quantum beat", extending the simplest case of the protofield quantum beat within every massive particle [1,3-6] to arbitrary system (or interaction process) leaps between its realisations, where the realisation change period $\Delta t = \tau$ becomes thus the generalised quantum beat period.

The system's *global state of rest* is then universally specified as the state with the minimum energy-complexity, $E = E_0$, for which the fundamental definition of energy, $E = -\partial\mathcal{A}/\partial t$, takes the form:

$$E_0 = -\frac{\Delta\mathcal{A}}{\Delta t} = \frac{\mathcal{A}_0}{\tau_0} = \mathcal{A}_0 \nu_0 , \tag{2}$$

where $\nu_0 = 1/\tau_0$ is the generalised quantum beat frequency at this complexity level, determining the corresponding *level of causal, naturally unstoppable and irreversible time flow* [1-6].

A *state of global system motion* (and thus motion as such) is universally defined as a state with the total energy-complexity greater than the minimum of the state of rest, $E > E_0$. It is actually obtained due to a *regular, inhomogeneous tendency* in the system realisation probability distribution violating the maximally homogeneous probability distribution in the state of rest (the latter corresponding to the limiting dynamic regime of uniform chaos [1-6]). Any global motion state can be described thus as *chaotic wandering* of the system generalised quantum beat process (represented by its generalised virtual soliton of regular, localised realisation state) around its average, global motion tendency (of realisation probability distribution). This universal structure of any system motion constitutes the general physical, *complex-dynamical* basis of *unified relativistic time dilation* at any level of complexity and time, since it is the *same* dynamic process of chaotic realisation change that gives rise to both global motion (regular average tendency) and physically real time flow (random deviations around the average tendency).

The inhomogeneous realisation probability distribution for a system in motion implies, mathematically, action-complexity dependence on the emerging space coordinate *x*, $\mathcal{A} = \mathcal{A}(x,t)$, leading to the universal expression for its total time derivative:

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

or

$$E = \frac{\mathcal{A}_0}{\tau} = \mathcal{A}_0 \nu = -\frac{\Delta\mathcal{A}}{\Delta t} + pv = \frac{\mathcal{A}_0}{T} + \frac{\mathcal{A}_0}{\lambda} v = \mathcal{A}_0 N + pv\,, \qquad (3)$$

where we have used the universal momentum and energy definitions (1), with the period of realisation change (generalised quantum beat) measured at the fixed space point $\tau = \Delta t\big|_{x=\text{const}}$ ($\nu = 1/\tau$ is the corresponding frequency), the size of emerging spatial inhomogeneity of the average, global part of moving system structure at the fixed time moment $\lambda = \Delta x\big|_{t=\text{const}}$, the "total" value of the quantum beat period in the moving frame $\Delta t = T$ ($N = 1/T$ is the corresponding frequency), and the global motion velocity $v = \Delta x/\Delta t$. Similar to the quantum complexity level [1,3-6], the second summand of the total energy partition (3), $pv = \mathcal{A}_0 v/\lambda$, describes the externally regular (but internally chaotic) global motion tendency, while the first summand, $\mathcal{A}_0 N = \mathcal{A}_0/T$, accounts for the purely random wandering of the system (represented by its generalised virtual soliton) around its global motion tendency. As noted above, *both* tendencies originate in and are therefore *related by* the *same* realisation change process (or generalised quantum beat), but the average dynamics tendency gives rise to the global system motion and related spatial inhomogeneity (generalising the simplest case of de Broglie wavelength at the lowest, quantum complexity sublevels [1,3-6]), while the random deviation tendency determines the internal time flow (at the considered, higher level of the hierarchy of time). It is clear therefore already from this general energy partition of eq. (3) that the period T and flow of internal time of a moving system is different from the externally measured time flow period τ $(T > \tau)$ and the difference grows with the system global motion energy and speed expressed by the pv term:

$$T = \frac{\tau}{1 - \dfrac{pv\tau}{\mathcal{A}_0}} = \frac{\tau}{1 - \dfrac{pv}{E}} \quad \text{or} \quad N = \nu - \frac{pv}{\mathcal{A}_0} = \nu\left(1 - \frac{pv}{E}\right). \tag{4}$$

In order to further specify this generalised time dilation effect (time dependence on the global motion), we can derive the *generalised relativistic dispersion relation* between *p* and *E*, determining the detailed proportion of the global motion (*p*) in its total amount (*E*). Following the actually universal derivation for the case of a massive elementary particle [3-6], we note that during the time $\tau_1 = \lambda/v_0$ of one causally random system leap between realisations within the global motion tendency (where $v_0 > v$ is the perturbation propagation speed in the lower-level component material), the system with the global motion speed v performs $n_1 = v_0/v$ causally random leaps, of duration τ each, within the purely random deviation tendency, which gives $\tau_1 = n_1\tau$, or $\lambda = V(v)\tau$, where $V(v) = (v_0)^2/v > v_0, v$ is the fictitious "phase velocity" of system motion needed to account for the difference between v and v_0, if we do not take into account random deviations from the global tendency (in the unitary, dynamically single-valued picture). Using expressions (1) for λ and τ in the obtained relation, we can rewrite it as the *generalised relativistic dispersion relation* between *E* and *p* (cf. [17], § 9):

$$E = pV(v), \text{ with } V(v) = (v_0)^2/v, \tag{5a}$$

or

$$p = mv, \tag{5b}$$

where

$$m = E/vV(v) = E/(v_0)^2 \tag{6}$$

is the *generalised relativistic mass* at the considered complexity level. Note that although the above "phase velocity" expression, $V(v) = (v_0)^2/v$, should be generally valid, it may be more correct to use its unspecified form, $V(v)$, in universal expressions covering also any highly uneven dynamic regimes. The complex-dynamical meaning of this general form of relativistic dispersion relation (5a), $E = pV(v)$, is that the system's total energy-complexity *E* is greater than its global motion energy $pv\,(= mv^2)$ (with $v < V(v)$) because of essential contribution from the random-deviation tendency (neglected in all usual, quasi-regular, and therefore "nonrelativistic", models).

Substituting now eq. (5a) into the universal energy partition relation (3) or (4), we can exclude the momentum variable *p* and obtain the universal time dilation expression in the form

$$T=\frac{\tau}{1-\frac{\upsilon}{V(\upsilon)}}=\frac{\tau}{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2} \quad \text{or} \quad N=\nu\left(1-\frac{\upsilon}{V(\upsilon)}\right)=\nu\left[1-\left(\frac{\upsilon}{\upsilon_0}\right)^2\right]. \qquad (7)$$

In order to replace the not directly measurable time period τ and frequency ν with the time flow period and frequency for the system globally at rest, τ_0 and ν_0, we can use a universally valid relation, $N\nu=(\nu_0)^2$, $T\tau=(\tau_0)^2$, expressing the internal complexity conservation [1,3-6], after which the *generalised relativistic time dilation* expression takes the canonical form

$$T=\frac{\tau_0}{\sqrt{1-\frac{\upsilon}{V(\upsilon)}}}=\frac{\tau_0}{\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}} \quad \text{or} \quad N=\nu_0\sqrt{1-\frac{\upsilon}{V(\upsilon)}}=\nu_0\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}. \qquad (8)$$

We emphasize once again that the obtained generalised time dilation, besides being valid for *any* system dynamics, has a well-specified *causal, complex-dynamic origin* (instead of the formal principles and expressions postulated in standard relativity) reduced to the *same* dynamic, interaction-driven origin of both irreversible time flow and global system motion.

Using eq. (8) and the generalised relativistic mass expression (6), we can now obtain the *generalised law of relativistic mass increase*, extending its usual version for mechanical motion [17] to any system dynamics and complexity level:

$$m=\frac{m_0}{\sqrt{1-\frac{\upsilon}{V(\upsilon)}}}=\frac{m_0}{\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}}\ , \qquad (9)$$

where the *generalised rest mass* m_0 is obtained from eq. (6) as

$$m_0=E_0\big/(\upsilon_0)^2\ , \qquad (10)$$

with the generalised rest energy E_0 expressed now by the extended, "quantum-and-relativistic" form of eq. (2):

$$E_0=m_0(\upsilon_0)^2=\frac{\mathcal{A}_0}{\tau_0}=\mathcal{A}_0\nu_0\ . \qquad (11)$$

The ultimate unification of *all generalised special relativity effects and generalised "quantum" (quantised, or dynamically discrete) behaviour* for any system and complexity level is obtained now as the detailed version of complex-dynamic energy partition (3) (using eqs. (5), (8)-(11)), which extends the respective relation for elementary particles [1,3-6]:

$$E=\mathcal{A}_0\nu_0\sqrt{1-\frac{\upsilon}{V(\upsilon)}}+\frac{m_0\upsilon^2}{\sqrt{1-\frac{\upsilon}{V(\upsilon)}}}=m_0\left(\upsilon_0\right)^2\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}+\frac{m_0\upsilon^2}{\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}}\ . \quad (12)$$

As the second and the first summand in this relation are proportional to the realisation change frequencies in the global motion tendency and purely random system wandering around it respectively, we find, by dividing the second term by the first, that $\alpha_1=(\upsilon/\upsilon_0)^2$ and $\alpha_2=1-(\upsilon/\upsilon_0)^2$ are the dynamically determined probabilities of finding the system in the former (average global) and the latter (purely random deviation) tendencies:

$$E=\frac{m_0\left(\upsilon_0\right)^2}{\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}}\left\{\left[1-\left(\frac{\upsilon}{\upsilon_0}\right)^2\right]+\left(\frac{\upsilon}{\upsilon_0}\right)^2\right\}=E(\alpha_2+\alpha_1)\ . \quad (12')$$

The state of motion is universally obtained thus as a *complex-dynamical, chaotic structure-forming process*, or *dynamically multivalued SOC* [1-6], with the emerging structure of elementary length $\Delta x=\lambda$ given by (see eq. (1)):

$$\lambda=\frac{\mathcal{A}_0}{p}=\frac{\mathcal{A}_0}{m_0\upsilon}\sqrt{1-\frac{\upsilon}{V(\upsilon)}}=\lambda_0\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}\ ,\ \lambda_0=\frac{\mathcal{A}_0}{m_0\upsilon}\ , \quad (13)$$

which expresses also the *generalised special relativistic length contraction*.

Similar to the performed generalisation of special relativity effects, *major effects of general relativity*, also originating in the underlying physically real, complex interaction dynamics, rather than in postulated "curved" and mixed abstract space and time [1,3-6], can also be extended to any system dynamics and complexity level [1,6]. The generalised *causal time flow change* and *mass transformation* at any complexity level for a system interacting with an external field (or environment) are obtained by the direct extension of the corresponding relation for elementary particles [1,3-6]:

$$M(x)(\upsilon_0)^2=\mathcal{A}_0\nu(x)=m(\upsilon_0)^2\sqrt{g_{00}(x)}=m(\upsilon_0)^2\sqrt{1+2\phi(x)}\ , \quad (14)$$

where $M(x)$ is the total system mass of the considered complexity level, taking into account the generalised relativistic contributions from both internal system dynamics and its interaction with the external field or environment with the dimensionless potential $\phi(x)$ ($|\phi(x)|<1$) and tension, or "generalised causal metric" $g_{00}(x)$ (usually $g_{00}(x)=1+2\phi(x)$, for weak field potentials $|\phi(x)|\ll 1$), and $\nu(x)$ is the generalised quantum beat (realisation change) frequency determining the causal internal time flow rate. Contrary to always attractive gravitational field effect with $\phi(x)<0$, leading to gravitational time dilation, in the general case one can have both $\phi(x)<0$ and $\phi(x)>0$ leading to either dilation (retardation) or compression (acceleration) of the internal causal time flow.

Inserting the generalised special relativistic mass (and time) transformation of eq. (9) for *m* in eq. (14), we obtain the *generalised total (special/velocity and general/field) relativistic transformation of causal time flow*,

$$\nu(x)=\nu_0\sqrt{\frac{g_{00}(x)}{1-\dfrac{\upsilon}{V(\upsilon)}}}\cong\nu_0\sqrt{\frac{1+2\phi(x)}{1-\dfrac{\upsilon}{V(\upsilon)}}}\cong\nu_0\frac{1+\phi(x)}{\sqrt{1-\left(\dfrac{\upsilon}{\upsilon_0}\right)^2}}\ , \tag{15}$$

and total mass (energy-complexity),

$$M(x)=m_0\sqrt{\frac{g_{00}(x)}{1-\dfrac{\upsilon}{V(\upsilon)}}}\cong m_0\sqrt{\frac{1+2\phi(x)}{1-\dfrac{\upsilon}{V(\upsilon)}}}\cong m_0\frac{1+\phi(x)}{\sqrt{1-\left(\dfrac{\upsilon}{\upsilon_0}\right)^2}}\ , \tag{16}$$

where ν_0 and m_0 refer to the system realisation change frequency and mass in the state of rest without external fields (see eq. (11)). In a similar way, we obtain the *unified relativistic length transformation* law from eqs. (13), (14):[1]

$$\lambda=\lambda_0\sqrt{\frac{1-\dfrac{\upsilon}{V(\upsilon)}}{g_{00}(x)}}\cong\lambda_0\sqrt{\frac{1-\dfrac{\upsilon}{V(\upsilon)}}{1+2\phi(x)}}\cong\lambda_0\left(1-\phi(x)\right)\sqrt{1-\left(\frac{\upsilon}{\upsilon_0}\right)^2}\ . \tag{17}$$

In order to illustrate the *unlimited application scope* of the generalised dynamic relativity effects thus derived from the underlying complex interaction dynamics, we can consider the well-known effect of *"psychological" time relativity*, or "subjectivity", for humans. While unitary science can hardly

[1] The obtained length transformation rule in the extended general relativity may have a reduced scope of validity with respect to the time and mass transformation laws, depending on the length orientation and dynamics with respect to the external field.

consider it as an objective phenomenon, providing at best only empirically based qualitative interpretations of psychological (as well as biological) time flow rate, the above laws of the universal complexity science imply not only objective and causal (dynamic), but quantitatively exact origin and description of those subjectively felt effects. In particular, strong "binding" (attractive-potential) external influences on individuals or social groups ($\phi(x)<0$) would imply internal, psychological time dilation of their subjects with respect to absent influences according to "general-relativistic" effect of the numerator of eq. (15) (cf. "happiness takes no account of time"), while the increased rate of internal development of a person, group, or society (e. g. for children and younger humans or developing societies) corresponds to the increased speed v in the "special-relativistic" denominator of eq. (15) leading to the internal time compression (growing $v(x)$), where standard calendar periods are perceived as longer subjectively. These results are easily generalised to various lower levels of *biological time* with respective practically important conclusions (including *aging dynamics* and feel).

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