Potential Reality I: Relative Scale Spacetime

D. Chakalov
35A Sutherland St
London SW1V 4JU, U.K.
Website chakalov.net

Abstract

Ensuing from first principles, a new theory of spacetime has been suggested, called 'relative scale spacetime'. It denounces the absolute size of objects at different length scales, thanks to which the phenomena known as quantum state ("just in the middle between possibility and reality", Heisenberg) and Einstein's "total field of as yet unknown structure" are unified as *potential reality* of quantum-gravitational origin (dubbed *causal field*), endowed with relative-scale metric. At macroscopic scale, it produces what is known as gravitation, without any dark matter nor dark energy.

1. Introduction

This is the first from three papers[1], presenting a theory of spacetime, based on the ideas of Plato, Heraclitus, and Aristotle. It is called *relative scale spacetime* (Fig. 15)[*], and is applicable to quantum, gravitational, and biological systems. The theory reflects my personal views (Sec. 5) on the foundations of Mathematics (Fig. 9 and Fig. 13) and adopts the philosophical doctrine about the design of the Universe, according to which it is both the only possible *and* the optimal one — Nature is *coherent*, therefore if we uncover the physics of life and solve[6] the mind-body problem, one could expect that such solution may outline *the* only possible theory of quantum gravity (Paper II[1]) as well. To reconcile life science with quantum gravity, I model the *physical* presentation of the Universe as 'Brain of the Universe', suggesting an universal *flow of events* defined with a new form of *retarded relativistic* causality applicable to quantum, gravitational, and biological systems, dubbed 'biocausality'[2] (Paper II), for which the so-called hyperimaginary numbers have been introduced (details in Paper III[1]). The proposition about mental "reflection"[21] or qualia from the Brain of the Universe (Universal Mind and The Holy Trinity) is considered 'absolutely undecidable' and will not be discussed. God as 'the Universe as ONE' is considered purely mathematical object, which is beyond our cognition and cannot be proved nor disproved.

This paper, dedicated to the centenary of Einstein's General Relativity[9] announced on 25 November 1915, suggests a new quantum-gravitational spacetime, in which the *size* of objects is not considered absolute, but 'relative to their length scale', hence the concept of *relative scale spacetime* (Eq. 2). In a nutshell, I suggest to abolish the presumption of absolute length scale and replace it with *relative* length scale: the "size" of an objects, say, a table with length 1m, is **dual**. On the one hand, it is indeed smaller with respect to the size of a galaxy and larger with respect to the size of a proton, but on the other, its (quadratic) invariant spacetime interval 1m is not only "flexible"[13] due to coordinate-free presentation of gravity (there is no background spacetime supplied by an ether, due to background independence), but is also *indistinguishable* from the size of a galaxy *and* the size of a proton — the *metric* in

[*] The latest version of the paper, with live links, can be downloaded from http://chakalov.net.

relative scale spacetime **changes** along the length scale (Eq. 2), in such way that a galaxy and a proton will have, within their respective length scale domains, the same *indistinguishable* relative-scale "size" of "1m" **as well**. Hence the quantum-gravitational spacetime begins from the macroscopic length scale of tables and chairs in two opposite "directions", toward the Large and the Small, and all physical objects *always* keep their *relative* and **dual** "size". This unique feature of relative scale spacetime might (**i**) facilitate the bootstrapping of the entire Universe by a topological "bridge" of all systems along the length scale (Table 1), produced by sharing a common quantum-gravitational *potential* reality (dubbed 'spacetime entanglement' in Paper II[1]), and (**ii**) open the possibility for spacetime engineering[63], provided the human *brain* can access such topological "bridge" (Paper III[1]).

With *relative scale spacetime*, the phenomenon known as 'gravity' is reduced to *variable relative metric* (not to "curvature"[44]), and the choice of tensors for mathematical presentation of gravity is considered **wrong**: the gravitational "field" is not classical objective reality 'out there'. If it were, it will be a force field, like the electromagnetic field, in which case the gravitational energy[11,12] will be localizable at a point[4] and the inertial mass of an accelerating particle will be a simple "back-reaction to its own gravitational field"[5], which in turn will render the *geometrization* of gravity impossible. The alternative viewpoint would be that gravity "does not exchange energy-momentum with both particles and electromagnetic field. So, it is not a force field, it does not carry energy-momentum" (private communication from Zhaoyan Wu), which makes the energy-momentum contributions of gravity pure magic. Either way, the unwarranted presumption in present-day General Relativity[32,60] that the gravitational "field" were objective reality subject to *classical* physics (cf. Sec. 3) will force us to choose from two options, both of which inevitably lead to dead end[6].

In my opinion, the only way to resolve the puzzle of how matter couples to its geometry[6] is to elaborate on the proposal by Plato and suggest a new kind of reality, called after Aristotle 'potential reality', which becomes *physicalized* by exerting energy-momentum *and* angular momentum in the physical stuff placed in right-hand side of Einstein's field equations, yet does **not** exist as objective reality 'out there'. Surely the *potential reality* is not 'mind' nor anything related to *res cogitans*, but a new kind of *physicalizable* reality "just in the middle between possibility and reality"[7]. In Quantum Theory, we encounter *quantum* potential realities in terms of quantum state and ultimately quantum vacuum, which are neither objective reality 'out there' nor plain mathematical abstraction. As Erwin Schrödinger stressed in 1935[8],

> In general, a variable *has* no definite value before I measure it;
> then measuring it does *not* mean ascertaining the value that it *has*.

In brief, I suggest *gravitational* potential reality, which casts its *physicalized* explications à la Plato in terms of invariant spacetime intervals with *variable* relative metric, resulting in *relative scale spacetime* (Fig. 15). The two main issues are (**i**) the relative scale "size" of objects (recall the example with one-meter table above) and (**ii**) the *emergence* of gravity due to alteration of the *variable* relative metric, producing force-free gravitational attraction and, at extragalactic scale, force-free gravitational "inflation" (Hubble flow). Hence (**i**) offers a global relational theory of 'space' with topological properties 'large' vs. 'small'[69], but without absolute length scale, while (**ii**) suggests the *origin* of gravity by reducing it to *local* effects of variable relative metric. (Recall that the current version of Einstein's theory of gravity[60] does

not even try to explain how the aggregation of matter could evoke the appearance[44] of gravitational "field".) The scope of 'relative scale spacetime' is full *geometrization* of gravity by recovering Einstein's "total field of as yet unknown structure"[9]:

> The right side is a formal condensation of all things whose comprehension in the sense of a field-theory is still problematic. Not for a moment, of course, did I doubt that this formulation was merely a makeshift in order to give the general principle of relativity a preliminary closed expression. For it was essentially not anything more than a theory of the gravitational field, which was somewhat artificially isolated from a total field of as yet unknown structure.

Briefly about the Ansatz of relative scale spacetime. After an overview of the theory, offered in this section, I will examine the proposal by Plato and the arguments for *gravitational* potential reality (Sec. 2). In the next two sections, I will suggest the origin of gravity as *local* alteration of the spacetime metric (full *geometrization* of gravity), and then offer conceptual solution to "the worst theoretical prediction in the history of physics!"[10], removing all "dark"[53] manifestations of gravity — there is no need for any *physical* stuff acting as "cold dark matter" nor as "dark energy", because the "shrinking" and "inflating" of the metric (producing in case (**i**) a "small" proton and a "large" galaxy, relative to a macroscopic table) are presented as force-free effects of the variable metric of relative scale spacetime. The force-free gravitational *rotation* will be examined in Sec. 4, as the phenomenon of torsion is considered an essential property of *gravitational* potential reality. In Sec. 5, I will offer a discussion of relative scale spacetime and will finish with an outline of the next Paper II[1].

The alternative, and strictly materialistic, view on the *origin* of spacetime bluntly ignores the proposal by Plato viz. the presence of *physicalizable* potential reality, and leads to "nontensorial"[12] (explanation below) nature of gravitational energy (*physical* energy-momentum tensor for the gravitational field does not exist[11,12]) and inherent energy non-conservation[13]. In my view, the current formulation of GR[9] cannot be applied to a spacetime point[4] nor to the observable universe, and is also based on mathematical jabberwockies[14], which I hope can be fixed by solving particular problems of the *continuum* of spacetime points, namely, by introducing 'potential reality' to point set topology, set theory, and number theory (Paper III[1]). To explain why we need to "insert" potential reality in the *continuum* of spacetime points, imagine a train moving along its railroad: we can suggest all sorts of alterations of the railroad (spacetime) to *geometrize* gravity, but these alterations cannot *in principle* encode the **engine** of the train — the railroad alone cannot *drive* the train. The train's engine is not present in the railroad, being the Aristotelian Unmoved Mover endowed with self-action[6] (dubbed Aristotelian Connection in Paper II[1]). Thus at every instant 'here and now' (Fig. 3), we've been passing through 'the Universe as ONE' (Luke 17:21) possessing indetermined numerical values, being *both* the smallest object called 'the atom of geometry' or simply 'point' *and* the largest object in "asymptotically" flat spacetime, located *exactly* at null-and-spacelike infinity (absolute infinity). Notice that the entire physical universe, equipped with metric[69], is "wrapped" by two presentations of 'the Universe as ONE', obtained by reaching the limit of the physical world at absolute infinity, yet these presentations cannot have metric and are indistinguishable, being "that which has no part" (Euclid). Stated differently, from the perspective of the length scale of the physical world equipped with metric, 'the Universe as ONE' looks *extremely* small or *extremely* large, while it is in fact one and the same *dimensionless* potential reality. There can be no metric[69] (P. Chrusciel[19], p.

226) in such luxonic realm[20], just as there is no size of the Platonic ideas placed "behind" the chained observers (Fig. 1), to claim that the *idea* of a tree is smaller than the *idea* of a mountain.

Let me begin with an explanation of the object referred to as 'potential reality'. Later I will introduce 'necessary and sufficient conditions for spacetime', arguing that one cannot *derive* the topological dimensions of spacetime exclusively from the physical stuff in the universe; hence the need for potential reality and 'causal field' as *sufficient* conditions for spacetime. Following Niels Bohr, I wish to stress that every sentence of mine should be understood not as an affirmation but as a question.

2. Potential reality: Causal field

The ancient idea that the physical world *emerges* from a different form of reality, for which I chose the term 'potential reality', can be presented with the famous 'allegory of the cave' by Plato, modified by adding an axis **W** (Fig. 1) from Fig. 4. The explicated world of physical "shadows" is cast on a continuum depicted with a film reel (Fig. 2) comprised from infinitely many (uncountably infinite) snapshots possessing indetermined "size", called spacetime points (Fig. 3), such that every spacetime domain of *finite* size (invariant spacetime interval with *relative scale* metric) is a set of such spacetime points, whereby the cardinality of such uncountable set is undecidable[15]. Every individual snapshot or frame (Fig. 2) is a **re**-created "shadow" (Fig. 1) obeying Einstein's equivalence principle ('no evidence of gravity'[16]), while the 'engine of the train' (see above) is the *light source* in Fig. 1. Only a *sequence* of such **re**-created frames (Fig. 2) can *assemble* the topological dimensions of the spacetime of physicalized "shadows", and *within* such sequence the law of energy **non**-conservation is mandatory[13] and we encounter gravitational radiation[17]. As Hermann Bondi remarked, the gravitational waves are real, "one can boil water with them!"[18]. Yet at every individual frame (Fig. 2), gravity is being *completely* **re**-eliminated and "conserved"[16] — once-at-a-frame, as read with a physical clock. Again, the topological dimensions of spacetime are obtained **only** by *assembling* the individual "shadows" to obtain a *sequence* of frames (Fig. 2), while the *duration* of the light along **W** (Fig. 1) is indetermined. If we picture the light source as a movie projector and the physical world as an *assembled* 4-D movie, we cannot notice whether the movie operator (not shown) have decided to, say, take a break and "temporarily" halt the movie, because her "time" pertains to the dark strips "between" the frames (Fig. 2). Such unphysical "time" pertains to light-like intervals[19] and to the atemporal[2] (with respect to a physical clock) *potential* reality living on the light cone[20] and "attached" (Paper III[1]) to quantum, gravitational, and biological systems[21], such as the human brain.

In the second paper (Paper II[1]), I will suggest *perfectly* continual trajectories of quantum-gravitational objects in *relative scale* spacetime, offering a different interpretation of the ideas of Kevin Brown[22]. Suffice it to say that the metaphor of a film reel (Fig. 2) is **wrong**: the *dark strip*, separating consecutive "frames", does **not** exist in Nature. Although we cannot imagine individual "frames" without something that would *separate* them, like the dark strips "between" the consecutive instances 'here and now', such cognitive "discreteness" is very misleading, because it makes the "frames" countable (Fig. 9) and suggests Hausdorff space, which are **illusions** (Fig. 13). To produce a *perfect* continuum of 'points and *nothing but points*', we have to ignore the convenient, but deadly wrong, idea of 'dark strips' and introduce brand new *structure* of the spacetime continuum by **dual topology** of every point 'here and now'

(Fig. 3), such that every (uncountably infinite) set of such points will yield a spacetime of *physicalized* points, **wrapped** by a *boundary* of potential reality (highlighted in **red**, Fig. 5), which will be called 'causal field'. Stated differently, I replace the expression 'asymptotic flatness at infinity' and all related jabberwockies[14] with 'causal field', stressing that the latter encodes the topological *structure* of spacetime points, known as 'time orientability' (P. Chrusciel[19], p. 247). Notice that the so-called causal field must **not** be *physical* reality[69], which would make it a *physical* Lorentzian ether at absolute rest or a *physical* 'reference fluid' fixing the points in space and their instants of time[23], but an *atemporal* luxonic[20] potential reality endowed with the *self-action* of the Unmoved Mover. Needless to say, the causal field is not *res cogitans* either[6], but the Platonic, *not-yet-physicalized* reality "just in the middle between possibility and reality"[7], residing in the *potential* future of biocausality[2]. Every spacetime event 'here and now' is the very *interface* (Fig. 3) "between" its past and potential future, possessing **dual** topology: it is both fixed in its irreversible past and *indefinable* in its potential future (causal field) spanned along the axis **W** in Fig. 4. At every physicalized event in the right-hand side of Einstein's field equations[22], the axis **W** (Fig. 4) is being **completely re**-nullified (resembling the Phoenix Universe of Abbé Georges Lemaître), to meet the requirements for *perfect* spacetime continuum (no "dark strips", Fig. 2) along the entire length scale.

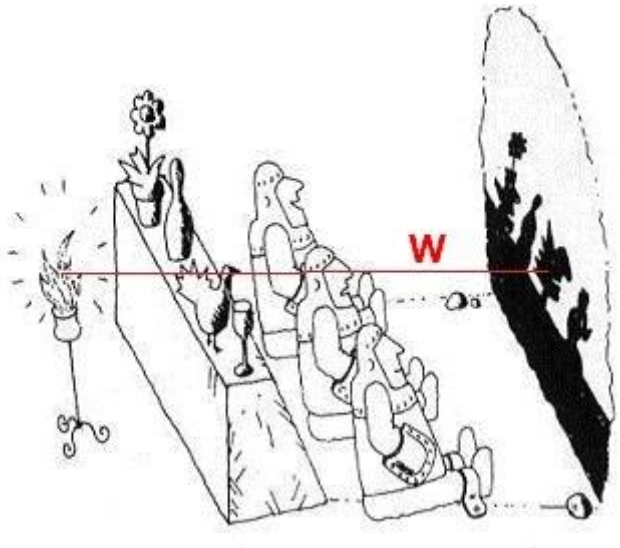


Fig. 1, adopted from Plato

Fig. 2

To produce *transience of time*, the physicalized "shadows" must **not** exist in the dark strips (Fig. 2) at which their Platonic ideas preserve their genidentity.

Also, our *physical* experience is comprised of *already* completed interactions[22], like one single event of emission-and-absorption of a photon (resembling clapping hands), and in this sense the *physical* "footprint" of the interface 'now' (Fig. 3), pertaining to the right-hand side of Einstein's field equations[22], is always **already**-fixed[66] in its irreversible past, while the *potential* "part" of the same interface 'now' (Fig. 3) always remains an *indefinable* 'causal field': *not-yet-physicalized* potential reality placed in the potential future[61] of biocausality[2], and endowed with an *extended* atemporal instant 'now' (but *not* with qualia[21]) along the atemporal[2] luxonic[20] **W** axis (Fig. 4). Were the *wegtransformierbar*[24] gravitational field a *physical* reality[4] (recall

the statements by Heisenberg[7] and Schrödinger[8] above), it will have to be "dark", which will lead to "the worst theoretical prediction in the history of physics!"[10].

Going back to the *interface* 'here and now' (Fig. 3 and point **P** in Fig. 4), which presents the notion of spacetime point or 'event', notice that the left-hand side of Einstein's field equations[22] is replaced with potential reality as 'causal field' (Einstein called it 'marble') residing in the *potential* future (highlighted in **red**, Fig. 3) and endowed with self-action (Aristotle), and also with *completed* or *actual infinity*, explained by David Hilbert (4 June 1925) as "a totality of things which exists all at once"[26]. The same interface 'here and now' (Fig. 3 and point **P** in Fig. 4) represents also the *physicalized* content of spacetime (Einstein called it 'timber'), placed in the *irreversible* past (highlighted in **blue**, Fig. 3) and endowed with never-ending *potential infinity*. The latter is crucial for making the *physical* manifold *perfectly* smooth (all sets and intervals are open) by infinitely differentiable (C^infty) "glue"[25] — no physical object could run out of points due to some mythical "geodesic incompleteness"[65]. The existence of "discrete" or quantized objects is beyond doubt, but, to use the analogy in the previous section about the *idea* of a tree and the *idea* of a mountain, keep in mind that such not-yet-physicalized, **intact**[29] objects are stored in the "memory" of the causal field (resembling aether and akasha), so their *apparent* "discreteness" does not lead to any "jumps" (*verdammten Quantenspringerei*, Erwin Schrödinger) in the quantum world *without* (Sic!) observers[29]: Dead matter makes quantum jumps; the living-and-quantum matter is smarter.

To make the **dual** topology of the interface 'here and now' (Fig. 3) easier to explain, I will call the causal field (marble), placed in the potential future, 'global mode of spacetime', and the *physicalized* — once-at-a-time[16] — mode of spacetime, placed in the irreversible past, 'local mode of spacetime' (timber). The axis orthogonal to the "inflated" local mode of spacetime, passing at **P**, is denoted with **W** (Fig. 4), from the German *wunderbar*, as a humble tribute to Theodor Kaluza. The ark **APB** (Fig. 4) shows the scale-dependent proper time and proper distance in *relative scale* (RS) spacetime.

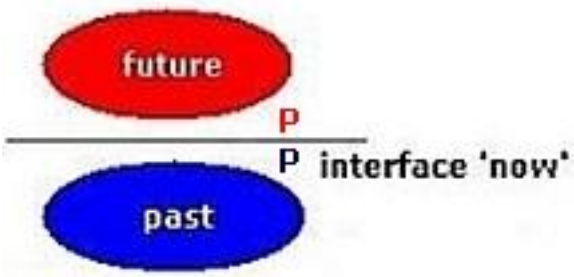


Fig. 3

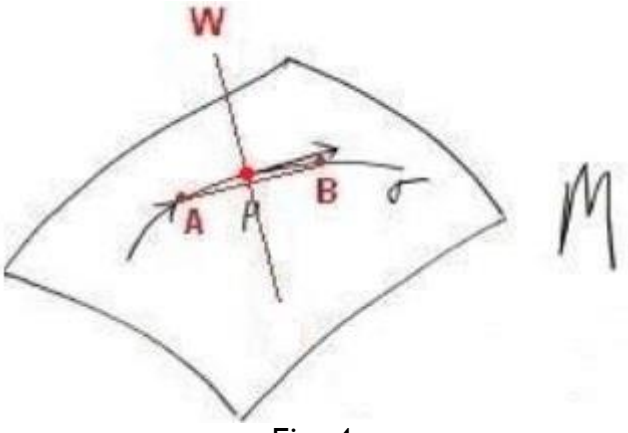


Fig. 4

Physically, the inflation time, matching the radius (Fig. 9 and Fig. 6) of the "inflating balloon"[46] (Fig. 4), is tending *asymptotically* toward The Beginning (John 1:1) and The End by never-ending *potential infinity* (highlighted with **blue**, Fig. 5), so the *physical* time can never *actually* reach it. In this sense, the *local* (physical) mode of spacetime

is “infinitely old because infinitely many things have happened since its beginning”[27]. On the other hand, the same cosmological time has *finite* duration **as well** (Fig. 10), as at every interface ‘here and now’ (Fig. 3) it is presented with a closed interval defined **by** the causal field and fixed with *actual infinity* (David Hilbert), in such way that every interface **P** ‘here and now’ (Fig. 5) is just as “real” as is The Beginning. In physical theology (see Case **IV** below), The Beginning (John 1:1) *was* (notice the temporal ordering of events) the union **M** ≡ **N** = **0** ∪ **AB** ≡ [absolute infinity], *after* which God as the Unmoved Mover created the spacetime (Luke 17:21). I believe this proposition is undecidable, as it cannot be falsified and presented with a theorem.

To sum up, I suggest ‘dual cosmological time’ and Finite Infinity[28] (Fig. 5; see Sec. 5), and the so-called ‘eye of the Universe’ (Fig. 8). Again, let me stress that there is a fundamental difference between ‘time as change *within* spacetime’ (the ark **APB** in Fig. 4), called ‘proper time’ and denoted with the Greek letter **τ** (tau), and its orthogonal complement ‘time as change of the spacetime itself’ along the axis **W** in Fig. 4. The genuine dynamics of General Relativity[9] is based on both cases of ‘time as change’. The first case pertains to physical, non-inertial observers endowed with *unending* potential infinity, while the second case corresponds to an orthogonal, ideal inertial “meta” observer endowed with unphysical *actual* infinity (Fig. 10), who can capture the evolving physical universe *en bloc* (Hubblesite), including the **red** ideal endpoints in Fig. 5, hence claim that the universe is always ‘finite’. Yet a physical, non-inertial observer will always claim that the same universe is ‘infinite’. Who is right? Wrong question. Both observers are “right”, thanks to Finite Infinity.

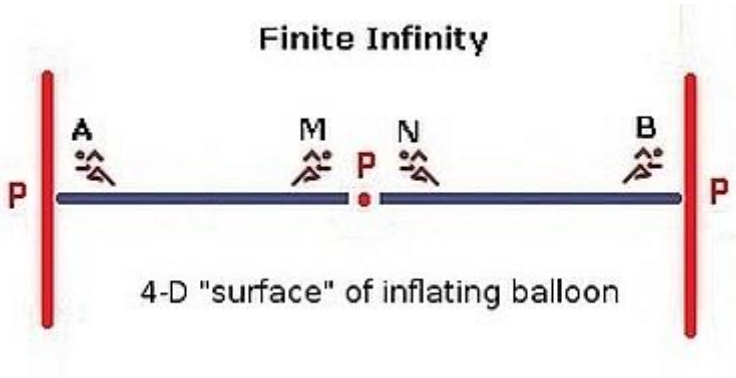


Fig. 5
P does not belong to **[AM] U [NB]**[69]

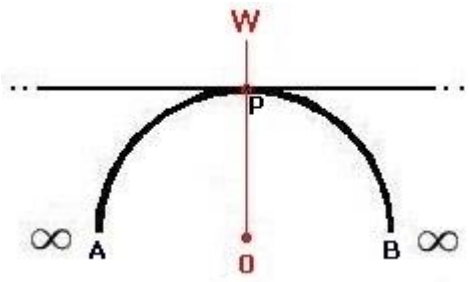


Fig. 6

With respect to the physical world equipped with metric[69], depicted with **blue** in Fig. 5 and in Fig. 3, the Universe as ONE (depicted with **red**) is both extremely “small” and extremely “large” Platonic object (like a “small” *idea* of a tree and a “large” *idea* of a mountain; see above), which does **not** belong to the local (physical) mode of spacetime. It (not “He”) is called ‘causal field’ (global mode of spacetime). It also acts as *unphysical* boundary “wrapping” each and every *interface* ‘here and now’ (Fig. 3) viz. the *entire* local (**blue**) mode of spacetime *en bloc*, presented in the current, and essentially incomplete[9], formulation of GR in the right-hand side of Einstein’s field equations[22]. Thus, the topological boundary, made by the causal field (depicted with **red**, Fig. 5), is not some *subset* of the topological space of the *physical* world, as suggested in the statements regarding topological boundary and topological interior:

the causal field is **not** some "subset" of the topological space pertaining to the *physical* world depicted with **blue** in Fig. 5.

Again, the causal field harbors the *potential*, not-yet-physicalized states of the physical world (see Heisenberg and Schrödinger above), which do **not** exist as an objective, non-contextual physical reality[3,29]. It is like the grin of the Cheshire cat[45] *without* the cat (Fig. 16): the grin is **not** a "subset" of cat's topological space.

Recall the existential definition of 'set' by Georg Cantor (7 November 1895)[30]: any gathering-together (*Zusammenfassung*) of determined and well-distinguished objects into a **whole** (*zu einem Ganzen*). Replace 'a **whole** (*zu einem Ganzen*)' with 'causal field' and keep in mind that both objects are purely mathematical. In the quantum-gravitational realm, the causal field casts a *physicalized* world (depicted with **blue**, Fig. 5), once-at-a-time[16], yet the causal field itself is **not** 'physical reality'[4] and does **not** "collapse"[29]. It can be ignored only in the macroscopic world of inanimate objects, described in classical physics, where its influence is vanishing small, yet **not** zero. The causal field is *potential* reality "just in the middle between possibility and reality"[7], and may have qualia[21], but this is relevant to its practical implications, such as spacetime engineering[63] (e.g., REIM), which will be examined later (Paper III[1]). To be a bit more precise, in relative scale spacetime all quantum, gravitational, and biological systems[6] constituting 'the Brain of the Universe' are endowed with an *extended* atemporal instant 'here and now'[21], depicted with the axis **W** in Fig. 4, while the physical **footmark** of **W** on the local (physical) mode of spacetime (**blue** line in Fig. 5) is **infinitesimal**, matching the "thickness" of the *interface* 'here and now' in Fig. 3. Even in the macroscopic world of tables and chairs, the *atemporal* "duration" of **W** (Fig. 4) is vanishing small but **not** zero, which marks the beginning of the causal field. Its effects *increase* along **W** and **0W** (Fig. 6), leading to what I dubbed previously 'entanglement of spacetime' (Sec. 1), but these effects are always *perfectly* localized **on** the local mode of spacetime (**blue** line in Fig. 5), once-at-a-time[16,29]. If we denote the so-called entanglement of spacetime (leading to topological "bridge", Sec. 1) with **w** , the effects of the causal field can be "spanned" along **0W** (Fig. 6) as follows:

Case **I**: $\mathbf{w} \rightarrow \mathbf{0}$, classical physics
Case **II**: $\mathbf{0 < w < \infty}$, quantum gravity and life sciences
Case **III**: $\mathbf{w} \rightarrow \mathbf{\infty}$, hyper physics (?)
Case **IV**: $\mathbf{w \equiv 0 \equiv \infty}$, physical theology. At the interface 'here and now' (Fig. 3), we pass through the Noumenon (Luke 17:21) at absolute infinity.

Table 1

The so-called hyperimaginary numbers (Paper III[1]) involve **w** , which becomes *physicalized* with its unique property $\mathbf{w^2 = 0}$, casting its "shadows" (Fig. 1) on the **physical** **footmark** of **W** , marked with the **blue** line in Fig. 5, including the real parts of imaginary numbers. The **intact**[29] Platonic case in which **w** is **not** squared pertains to an extended atemporal presence 'now'[21] along the non-squared **w** viz. the effects of the causal field in Cases **I** - **III** in Table 1 above, as **w** lives "within" light-like intervals[20], constituting the luxonic or 'global mode of spacetime'.

Regarding Finite Infinity, let me show the Universe as ONE (the **red** objects in Fig. 5) *exactly* at infinity: the ark **APB** in Fig. 4 is depicted at *absolute* infinity in Fig. 6 with a horizontal black line and, due to the absence of any metric there, **AP** = **PB** = **Ø**. All physical points along **APB** will superimpose and fuse into one single point (John 1:1), together with The Beginning at **0** and the causal field along **0W**. Obviously, the metaphysical notions of 'infinity', 'empty set' Ø and 'zero', and 'point at infinity' are completely devoid of specific substance, yet need exact mathematical clarification.

To sum up, in relative scale spacetime the endless *physical* world[56] passes through 'the Universe as ONE' at absolute infinity, once-at-a-time[16], by non-smooth sphere-torus transitions (Fig. 7), **trespassing** (Sic!) the black horizontal lines at absolute infinity in Fig. 6 and Fig. 7. The murky expression 'asymptotic flatness at infinity' is replaced with *quasi-flat* spacetime being *infinitesimally* close to **both** closed spacetime (sphere, Fig. 6) with maximal size tending asymptotically toward infinity, **and** open spacetime (torus) with maximal size tending asymptotically toward infinity. Namely, the **blue** horizontal line in Fig. 5 is not "flat" but is tending *asymptotically* toward the horizontal lines in Fig. 6 and Fig. 7, from both "south" (sphere) and "north" (torus). These hypothetical topological *waves* of the causal field (global mode of spacetime) remotely resemble quantum waves, as their non-squared "amplitude" **w** along **0W** (Fig. 6) is also unphysical. Perhaps one can expect various physical effects by tweaking their hyperimaginary *phase* (Paper III[1]). Perhaps spacetime engineering[63] can only be performed *effortlessly*, much like the way we "move" our thoughts[21], but with the Law of Reversed Effort: when the mind is still, the universe surrenders (Lau-Tzu).

The so-called 'eye of the Universe' (Fig. 8) shows the causal field (depicted in **red**), immersed into a *colorless* area presenting a *bona fide* Noumenon (*Das Ding an sich*), also known as 'the true monad without windows' (Leibniz). It is an omnipresent **non**-reality, which explicates its physical and mental content as *colored* reality. It is 'the unknown unknown', resembling some physical-and-cognitive vacuum, explicated along the **W** axis (Fig. 4) by genuine *creatio ex nihilo*. It (not "He") can never be exhausted, not even during an infinite cosmological time. As John Wheeler put it, "Time is Nature's way to keep everything from happening all at once."[31]

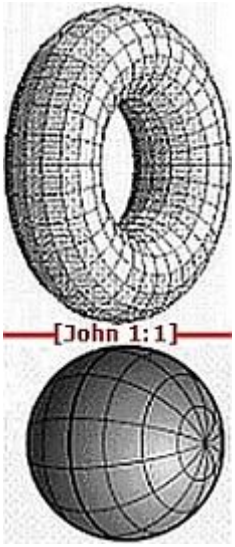
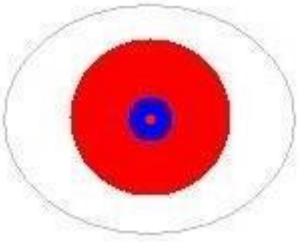


Fig. 7

The eye of the Universe



Physical (**blue**) and potential (**red**) present two forms of reality (Fig. 5), complemented by an omnipresent colorless **non**-reality, the Noumenon.

Fig. 8

The *union* of colored reality (**red** and **blue**) and *colorless* **non**-reality should correspond to the incomprehensible 'Universe as ONE', known as God (John 1:1; Luke 17:21). It cannot be grasped with human cognition: we operate with 'sets' but cannot produce the ultimate 'set of all sets', if any. No statement about God's existence can be presented with a theorem that can be proven true or false, hence reduce God to science and Mathematics. Thank God, this is impossible.

In Sec. 3 below, I will offer specific arguments in support of the main ideas in Fig. 3, and will also 'put my cards on the table' by providing the conditions under which the entire theory[1] *can and will* be rejected (Fig. 11). Then in Sec. 4 I will suggest the *origin* of gravity by reducing it to dynamic relative-scale metric, and Sec. 5 will present the current unsolved problems — *nur die Fülle führt zur Klarheit, und im Abgrund wohnt die Wahrheit* (Friedrich von Schiller).

3. Verification of the main ideas

In Sec. 2, I tried to explain the proposal for relative scale (hereafter RS) spacetime. Here I will do my best to verify the theory by showing where it comes from, and will begin with the most controversial, in my opinion, hypothesis in the current, and essentially incomplete[9], mathematical relativity, known as 'locally Minkowskian'.

We are led to believe that, in a "sufficiently small"[32] neighborhood around every spacetime point (see the "running guys" in Fig. 5), one can "erect a locally inertial coordinate system in which matter satisfies the laws of special relativity"[32]. In my opinion, the slippery boundary of such "sufficiently small"[32] neighborhood is sheer poetry, not even an operational definition. What people call "sufficiently small" neighborhood refers to a **finite** (Sic!) spacetime domain[69], yet it does not have **numerical value** along with *acceptable* error margins to determine 'sufficiently small'. The same objection applies to 'sufficiently large' spacetime domain at which people suggest asymptotic flatness at "infinity"[49], as well as to the "small" yet **finite** distance between neighboring congruent geodesics: one cannot define limits with Eq. 1.

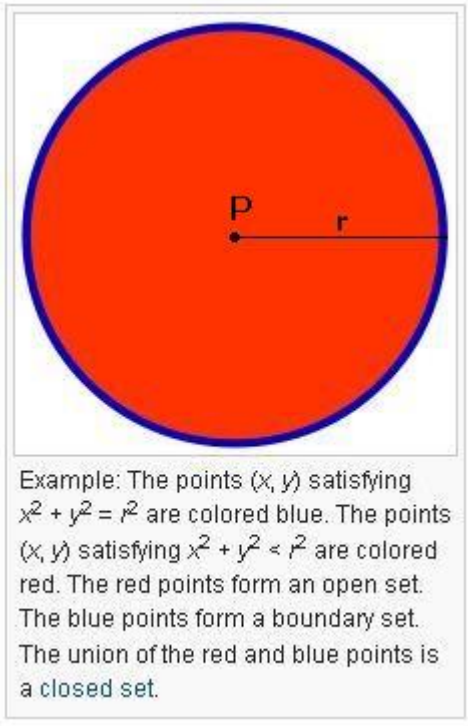
The **numerical values** of 'sufficiently small/large' can be defined only with the exact – not slippery – boundary of an open set determined with the diameter **2r** of a ball with center **P** (Fig. 9). If we picture a **finite** spacetime domain[69] as a ball with center **P** and radius **r** (Fig. 9), it can be defined only with the (ε, δ)-definition of limit applicable to **finite** objects and based on actual infinity[26]. An explanation from a bartender runs as follows (Fig. 10):

> An infinite crowd of mathematicians enters a bar. The first one orders a pint, the second one a half pint, the third one a quarter pint... "I understand", says the bartender - and pours two pints.

But the (ε, δ)-recipe for obtaining the *exact* size of 'two pint beer' (Fig. 10) cannot be used in GR[32] to define a 'small' spacetime domain, not to mention '*sufficiently* small'. If we cut an apple into two pieces, we may claim that there is a "sufficiently small" neighborhood around its center, occupied by its seeds, yet such neighborhood *and* the exact boundaries[49,65] of the **finite** apple (cf. the diameter **2r** in Fig. 9 and the two pint

beer in Fig. 10) must be defined *relationally*, with respect to both (**i**) the *unphysical* center at **P** (Fig. 5) and (**ii**) the *unphysical* boundaries[65] called causal field (highlighted with **red** in Fig. 5), residing "within" **P as well**.

Thus, I suggest to treat **P** as an *interface* 'here and now' (Fig. 3), and endow **P** with **dual** topology to solve the problems of localization of gravity[4] and *the* quantum state[29].



Example: The points (x, y) satisfying $x^2 + y^2 = r^2$ are colored blue. The points (x, y) satisfying $x^2 + y^2 < r^2$ are colored red. The red points form an open set. The blue points form a boundary set. The union of the red and blue points is a closed set.

Fig. 9, adopted from Wikipedia

The two endpoints belong both to the two pint beer and to its ambient environment around the beer

Fig. 10

Let me explain. First, the "thickness" of the blue boundary in Fig. 9 above cannot be that of one *single* point or "frame" **separated** by "dark strips" (Fig. 2), because it will make such individual *single* point **countable**, as stated above. We can only *imagine* one single red point **P** in Fig. 9 and one single blue point to *define* the radius **r** , because these two points are uniquely defined with their "coordinates", even though we cannot see the "next" red point placed to the left of **P**, which does not already belong to **r**. But all this is based on pure imagination. We claim that the "number" of points constituting **r** is Aleph-0, although Aleph-0 plus/minus *one* point is again Aleph-0, so we cannot actually define individual points, yet they are needed to *define* **r** with our imagination. Well, Nature does **not** work with imagination[14,49].

The genuine *perfect* continuum of 'points and *nothing but points*' (Fig. 3) contains uncountably infinite points, which form a set[15] with **undecidable** cardinality[33]. Thanks to Thomson's lamp paradox (see below), none of the colored points in Fig. 9 can be *individuated* viz. counted, which is why there is no difference *whatsoever* between countably infinite sets with the alleged cardinal "number" aleph-0 and uncountably infinite sets with **undecidable** cardinality[33]: aleph-0 is *undecidable* as well, and no 'number' can designate the infinite points assembling the number line in Fig. 10.

What we call ‘spacetime point’ is the very *interface* ‘here and now’ endowed with **dual** topology (Fig. 3), thanks to which its ‘potential reality’, with footprint on the *physical* reality (Fig. 17) marked with **blue** in Fig. 3, is spanned along the unphysical axis **W** in Fig. 4 and **W0** in Fig. 6 **as well**, leading to the so-called hyperimaginary numbers (Paper **III**[1]) and to physical theology, as explained in Table 1 above. The presentation of blue points forming a “boundary set” in Fig. 9 is false, because it **requires** a “dark strip” (Fig. 2) inserted somehow **]**between**[** the “boundary set” and the “open set” in Fig. 9.

Such “dark strip” does not exist in Nature. It is a grave misconception, which makes the continuum problem[33] insoluble and leads to mathematical jabberwockies[14,49].

NB: The localization of gravity[16] is only and exclusively only **on** the *physical* footmark of **W** (Fig. 4), which is placed in the irreversible past depicted with **blue** in Fig. 3. The *potential* gravitational state (Fig. 16), residing in the potential future of *the same* interface ‘here and now’ (Fig. 3), does **not** exist in the *physicalized* state[24] in the **past** (see Fig. 17 and the analogy with the Cheshire cat[45] above), which is why one can “eliminate” it by hand[4]. The same applies to the **intact** quantum world[29].

Without such distinction between the two “components” of gravity, physical (Fig. 17) and potential (Fig. 16), we cannot understand Einstein’s equivalence principle (‘no evidence of gravity’[16]) and the localization of gravity is impossible *in principle*. The same conceptual solution applies to the *potential* quantum state and its localization; the problem is widely known since 1911, thanks to Charles Wilson, which is why I consider it *the* most widely known public secret in theoretical physics[29].

The explanation of the so-called “sufficiently small”[32] neighborhood, in which the spacetime were ‘locally Minkowskian’, is straightforward: it is not “small”, but pertains only and exclusively only to the *physicalized* gravity placed in the irreversible past, depicted with **blue** in Fig. 3. Hence we can ‘catch two birds with one stroke’: the localization of gravity and Einstein’s equivalence principle are two facets of the same gravitational phenomenon, while the second ‘bird’ is the localization of the quantum state[29] — check out Heisenberg[7] and Schrödinger[8] above.

The joint solution to these two problems, presented as localization of the quantum-gravitational *causal field* (see **NB** above), also explains the puzzle of the energy density of the vacuum[34] and resolves what has been called “the worst theoretical prediction in the history of physics!”[10]: if we treat the causal field as ‘nothing but physical reality’, the energy density of the quantum vacuum, with cutoff at Planck scale[35], will correspond to “a mass density of about 10^{96} kilograms per cubic meter!”[34], and there will be an enormous “dark”[53] manifestation of gravity in terms of “cold dark matter” and “dark energy”.

Moreover, the current theoretical physics will need some Biblical “miracle” to raise a robust Lorentzian metric within 10^{-30} seconds “after” the “big bang”, starting much earlier at 10^{-35} seconds “after” it (the spacetime metric is already postulated), when the spacetime were just about 1 cm across and a causally connected region would have been only 10^{-24} cm across (the horizon problem), in such way that one could “inflate” the spacetime by a factor of 10^{78} and then safely keep the Lorentzian metric for at

least 13.798 ± 0.037 billion years rooted on the Planck scale[35] at which the spacetime points have become totally fuzzy and locality has lost *any* meaning[36].

I will assume that no "miracles", included those performed for profit[37], are acceptable in science, and will proceed further by declaring the conditions under which the whole theory *can and will* be rejected.

Consider the dynamics of General Relativity[60] exhibited in the transport of energy by gravitational waves (GWs): the phenomenon is genuinely *non-linear*[18, 68], and no linearized approximation[17] can be applied for detecting the *physicalized* energy of GWs. I will also presume that the theory suggested in **NB** above is either *true* or *false*. So if it is proven *false*, I will immediately trash it.

The condition for proving the theory *false* is to demonstrate that the textbook presentation of GR as *classical* theory[38] is indeed correct. If so, we have only two alternatives for explaining the transport of energy by GWs: either they are (**i**) *physical* waves capable of transporting energy, momentum, and angular momentum along a continual path, or (**ii**) GWs are *not* physical waves and therefore they cannot transport any physical stuff, much like the quantum waves. Again, notice that such *alternative* framework, either GWs are physical or not, is mandatory for a *classical* theory[69].

As an example for continual path of energy transport by GWs, consider PSR J1603-7202[39], with *dimensionless* amplitude 2.3×10^{-26}: case (**i**) requires that their *intangible* energy (Sir Hermann Bondi[13]) is being converted into some physical (tangible) energy at each and every point[4] along the path from PSR J1603-7202 to Earth[39]. To prove case (**i**) possible, at least in principle, the proponents of GW "astronomy"[39] must use the only available theory of gravitational radiation, suggested by Sir Hermann Bondi in 1961 (private communication from Josh Goldberg) and published one year later[18], and of course abandon the *linearized* approximation[17]. Here's a simple example of case (**i**), depicted in Fig. 11:

> Imagine an empty plastic bottle on your desk, trespassed by GWs from PSR J1603-7202[39], with dimensionless amplitude 2.3×10^{-26}, and explain the coupling[17] of their wave strain to the plastic material of the bottle, leading to stresses[40]. How could gravitational radiation[18] produce **work** to induce stresses[40] *and* squeeze the bottle ? Perhaps at 2.3×10^{-26} m ?

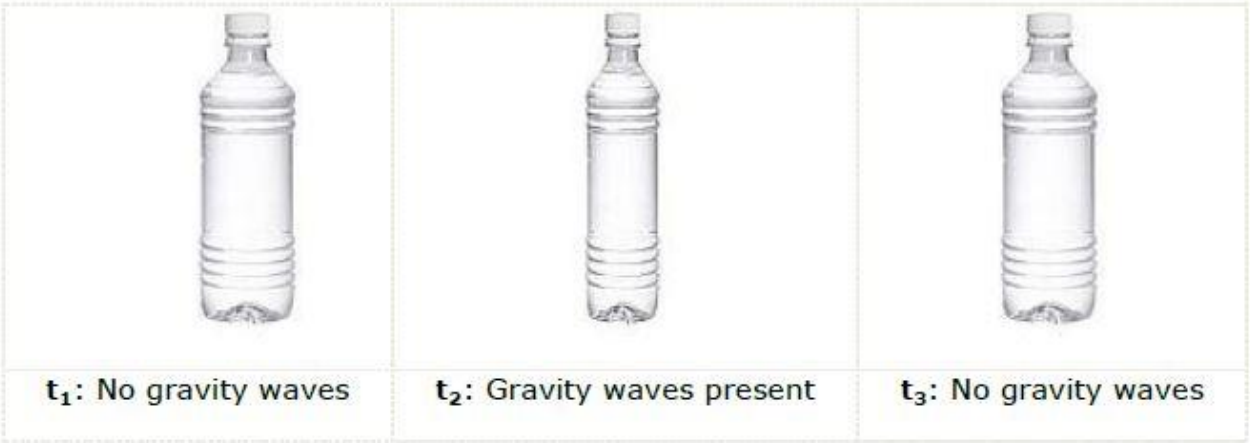


Fig. 11

Even if this formidable task is achieved and case (**i**) proven correct, at least in principle, the dynamics of GR will be reduced to describing some *physical* gravitational field, which in turn requires that its localization[4] and energy conservation[13] will be possible with such *classical* theory — *reductio ad absurdum*. The alternative case (**ii**) requires that GWs are fictitious objects[41] that cannot transport any physical stuff — *reductio ad absurdum*, again.

Thus, the initial presumption that General Relativity[9] were *bona fide* classical theory is proven **wrong**, and the only possible theory, by means of logical choice, is the one presented in this paper. Yes, GWs transport energy, momentum, and angular momentum, but only and exclusively only by their localization explained in **NB** above. Hence we can 'have our cake and eat it'.

Needless to say, if case (**i**) *or* case (**ii**) is proven correct, the entire theory[1] will be trashed and I will switch to other activities, say, to raising tomatoes in my garden.

Meanwhile let me outline the new form of causality, dubbed biocausality[2], and suggest 'necessary and sufficient conditions for spacetime'.

In the outline of the theory presented above, the quantum-gravitational *potential* reality, called causal field, *complements* the physical reality placed in the past and marked with **blue** in Fig. 3. The latter forms the *necessary* condition for spacetime, while the former is considered *sufficient* condition for spacetime. Their causality is called biocausality[2], covering Cases **I** – **III** in Table 1 above. It is relativistic causality, conforming to the metaphysical principle of locality, and retarded causality, because the "dark strip" (Fig. 2), which would allow for advanced causality viz. tachyons, does **not** exist in the *perfect* continuum of instances 'here and now' (Fig. 3). If the Planck scale[35] were *nothing but physical* reality, resembling an individual (hence countable) pixel in a digital image, the spacetime would be fundamentally discrete and one could recover the size of every finite object *exactly*, say, a table with length 1m would be recovered by multiplying the Planck length by its reciprocal value, $1.616199(97)\times10^{35}$. If this was the case chosen by Nature, the set of such *extended* points, constituting 'one meter', will have **countable** cardinality of extended points plus extended "dark strips" between them (Fig. 2), the "dark strip" will be the ultimate cutoff at Planck scale[35], and Cantor[15] will be wrong, because the spacetime will possess Archimedean topology[69] and 1m will contain *less* countable points than one cube with rib 1m.

Let me show how the interface 'here and now' (Fig. 3) can be derived from the limit of a sequence. First, see Thomson's lamp paradox, which will be explained here with the limit **1** minute:

> Consider a lamp with a toggle switch. If flicking the switch once turns the lamp **on**, another flick will turn the lamp **off**. Now suppose that there is a being endowed with *infinite* time, and able to perform the following task: starting at time zero, she turns the lamp **on**. At the end of half minute, she turns it **off**. At the end of another quarter of a minute, she turns it **on**. At the next eighth of a minute, she turns it **off** again, and she continues thus, flicking the switch each time after waiting exactly one-half the time she waited before flicking it previously. The sum of this infinite series of time intervals is exactly one

minute. The following question is then considered: Is the lamp switched **on** or **off** after *exactly* **one** minute?

The alleged paradox is based on mixing apples (**MN** in Fig. 5) with oranges (**P**): the lamp is always a *finite* physical stuff possessing *unending* potential infinity, depicted with the finite interval **MN** in Fig. 5, while the endpoint or limit at *exactly* **1**m is reached only with *actual* infinity (Fig. 10), which must **end** at the endpoint **P** in Fig. 5. To explain the paradox, imagine that you are about to enter a tunnel by foot, and the tunnel has a diameter of, say, 2m. As you walk in the tunnel, you measure its diameter at every 10m, and also notice that both you and the tunnel are shrinking by 10cm at every 10m. So at some remote point of your journey, you have to **stop**, because you just can't move further: you (not the tunnel) have become the smallest *physical* object **MN** and cannot "disappear" (Eq. 1) in order to reach the *calculated* (with **actual** infinity) limit at which the diameter of the tunnel might supposedly shrink to **zero**, hitting the endpoint **P**. You may *imagine* that your state at **MN**, at which you can't move further, *might* be 'exactly the same' as at the *calculated* limit at **P** performed with **actual** infinity, but you can never be certain, because the actual endpoint at **P** (Fig. 5) is unreachable to you: you are **physical** object of **finite** size[69]. Surely at the smallest yet finite **MN** (Fig. 5) the state of your lamp is **definitive**, but you wrongly *imagine* that if you could (only you can't) use **actual** infinity to reach the endpoint **P** of 'zero diameter' of the tunnel 'in front of you'[49], the state of your lamp would be **definitive** as well, and then you ask the tantalizing question, 'what *is* the **definite** state of my lamp at both **MN** and **P**?', which is mixing apples with oranges. Your "reasoning" is nothing but *counterfactual* supposition, and secondly – your *finite* extension of **MN** can accommodate *any* state of your lamp: the "number" of such allowed states *within* **MN** is *uncountably infinite* (Sic!), but since your lamp has only two alternative states, you claim that the state of your lamp at **MN** will be *either* **on** *or* **off**. Fine, but there is no *definite* lamp at **P**, simply because there is no 'lamp' there (Fig. 16). Only a *superposition* (Paul Dirac) of states |on> and |off>, like Schrödinger's cat[29]. You will always obtain some *definite* value of your lamp at **MN**, either **on** or **off**, but only **after** you perform the "measurement" at **MN**, which "does *not* mean ascertaining the value that it *has*"[8] (cf. Schrödinger) at **P** (Fig. 5). In GR[56,60] this leads to various pseudotensors suggested to calculate the gravitational analog of lamp's states |on> and |off>, despite that (**i**) the "linear" connection (the Christoffel symbols[4]) is *atemporally* **non**-linear (Fig. 18), and (**ii**) the energy-momentum of gravity[13] is not 'physical reality' like the Moon[3], but *wegtransformierbar*[24] *potential* reality[63] (Fig. 16). Physically, it may be eliminated by hand[4,34] or by "collapse"[29]. Its localization is only on the *physical* (**blue**) footmark of the causal field: see **NB** above.

Again, the fundamental difference between **MN** and **P** is that the former is physical stuff operating with unending *potential* infinity, while the latter is obtained only by actual/completed infinity[26], just like the limit 'two pint beer' in Fig. 10. And since **P** in Fig. 5 has **dual** topology, being the *interface* **P** 'here and now' in Fig. 3, we can *think* of the infinitesimal **MN** as having an exact limit, $\mathbf{MN} \rightarrow \mathbf{P} = \mathbf{1}$, but only to the extent to which **P** has a physical footprint or "component" placed in the *irreversible* past, marked with **blue** in Fig. 3. There are no numbers in Nature; only infinitesimal *physical* footprints in the **past**, thanks to which we can *imagine* some "fixed" number there.

We can *imagine* in Fig. 5 that **MN** = ∅ (notice $R_\infty = \varnothing$ in Fig. 12 below), but only to the extent to which its limit **P** (Fig. 3) has a *physical* "component" in the **past**. Yet the

interface **P** in Fig. 3 has a *potential* "component" **as well**, which is placed in the *potential* future and is considered 'potential reality' (Fig. 16). Hence no *physical* stuff, depicted in Fig. 5 with **MN**, can "collapse" on the **entire** *interface* **P** endowed with **dual** topology (Fig. 5 and Fig. 3). This is the reason for augmenting the current number theory with hyperimaginary numbers (details in Paper **III**[1]).

Now compare the endpoint **1** in Thomson's lamp paradox with the endpoint in Fig. 12 below (adopted from Lakoff and Núñez[42]), labeled also with **1**.

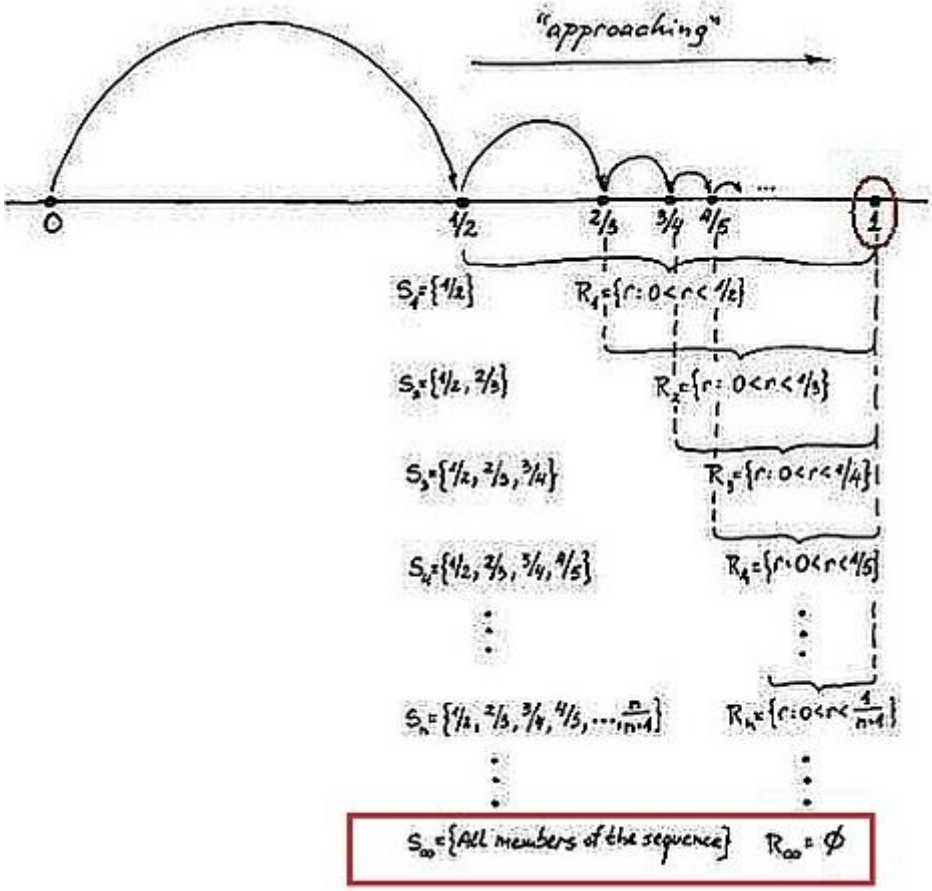


Fig. 12, adopted from Lakoff and Núñez[42]

Here the process of *approaching* the limit **1** pertains again to the unending potential infinity, and $\mathbf{R_n}$ in Fig. 12 matches **MN** in Fig. 5, while the endpoint **1** is reached *only* with actual/completed infinity[26] (see the largest beer in Fig. 10).

Every *finite* region of spacetime, denoted with **MN** and **AB** in Fig. 5, is being *assembled* with both potential and actual infinities (see Finite Infinity in Sec. 5), but what could possibly define the obvious *difference* between **MN** and **AB** in Fig. 5 ? There is no number, denoted with **k** [69], to obtain **AB** from the smaller **MN** by **k.MN** = **AB**, as in the definition of international second. If we decide to use actual infinity to *imagine* (not calculate) the alleged *limits* of **MN** and **AB** in Fig. 5, we will end up with a nonsense:

0 x **∞** = **1** (Eq. 1).

But if we use actual infinity, pertaining to 'potential reality', to calculate the invariant size of **MN** and **AB**, we can obtain clear fixed results (Fig. 10). If **MN** denotes the size of a proton[64] and **AB** the size of a galaxy (e.g., Milky Way), obviously **MN** << **AB**. Fine, but we cannot use some number **k** nor Eq. 1 to *derive* **AB** from **MN** (Fig. 5), since **MN** and **AB** are built by "the same" *undecidable* and nondenumerable **dual** (Sic!) object **P** (Fig. 3), which "has no part" (Euclid).

4. Relative scale spacetime

Before moving further, let me present in Fig. 13 some of the misleading ideas in the current set theory[33] (Fig. 9) and in mathematical relativity[14], originating from Fig. 2.

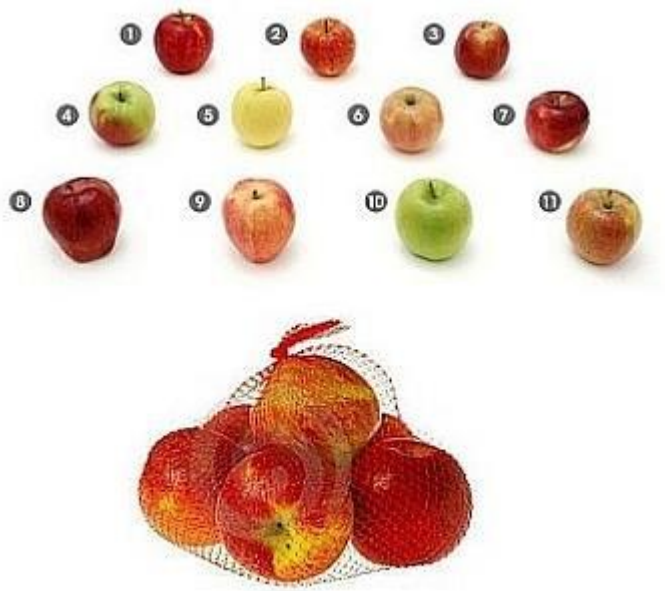


Fig. 13

The *union* of (i) the bag of apples and (ii) the air between apples (Fig. 13) does **not** belong to the apples themselves (Fig. 17). It is a "colorless" (Fig. 8) object, which exists in *every* set[30] by its *colorized* presentation as 'potential reality' (Fig. 16).

Again, it is not *res cogitans*[6]. It does **not** belong to the *members* of *any* set either. It is Platonic reality (Fig. 1), "just in the middle between possibility and reality"[7]. In this sense, every set[30] is *quantum set*, although in Case **I** in Table 1 above the presence of *potential* quantum-and-gravitational reality can be safely ignored.

The misleading ideas in Fig. 13 originate from Fig. 2, because many people interested in mathematical relativity[14] tacitly presume that the notion of an isolated, identifiable macroscopic apple (see **MN** above), which is denumerable and can be associated with a number[69], can be applied to the very *boundary* in Fig. 9, with radial extension of one single point. But in fact, the boundary is "that which has no part" (Euclid): the *interface* 'here and now' shown in Fig. 3 and Fig. 5. Hence the spacetime continuum[33]

is *perfect*, because all members of *quantum* sets are **wrapped** by their potential reality shown in Fig. 3 as potential "component" of the interface **P**. Physically, we see only *physicalized* apples placed in the **past** (highlighted with **blue** in Fig. 3). In the physical world depicted with **MN** and **AB** in Fig. 5, there is no *physical* boundary whatsoever. The unphysical "boundary" is made by nondenumerable potential reality (highlighted in **red** in Fig. 3 and Fig. 5). Unlike in Plato's proposal (Fig. 1), it cannot emit nor reflect light, and many people consider it "dark"[53] (more on this issue later).

Notice that the bag of apples in Fig. 13 and the two pint beer in Fig. 10 have *referential* background, while in the drawing of "expanding" universe (Hubblesite) the role of referential background is played by unphysical inertial "meta" observer, who can capture the entire physical spacetime *en bloc*, including its boundary. Following the discussion of the infinitesimal **MN** after Thomson's lamp above, such boundary belongs to the physical world only to the extent to which its limit **P** (Fig. 3 and Fig. 5) has *physical* "component" located in the irreversible **past**[69]. Hence the spacetime boundary has **dual** topology, because it also has *potential* "component", which does **not** have Archimedean topology[69] and is located in the *potential* future (**red**) of the same interface **P** (Fig. 3 and Fig. 5).

Now, before explaining the Ansatz of relative scale spacetime (Fig. 15), let me stress "the lack of cosmological models with realistic, gravitationally bound objects"[47]: we still do **not** understand the gravitational radiation[18], do **not** know how to detect it[17], and certainly cannot "install" mirrors (Sic!) for gravitational waves *exactly* at the joint "border" of the spacetime at null-and-spacelike infinity, to obtain gravitationally closed system and prove that the mass of the physical "shadows" (Fig. 1) is indeed positive (positive mass conjecture). People try to suggest an unrealistic "vacuum spacetime" which supposedly admits a "smooth conformal completion"[48] à la Penrose[49] and even offer Penrose diagrams with "compactified coordinates"[50], totally ignoring the unsolved mathematical problems of kinematical spacelike infinity (spi)[51,52] and the underlying mathematical jabberwockies[14,49].

To introduce the prerequisites to relative scale spacetime (see Fig. 15 below), notice that the inflating[55] ark **APB** in Fig. 4 is not at all "curved"[44], as many people[54] wrongly imagine. The dimensionless scale factor, pertaining to the inflating **APB** and to 'time as measured with a clock'[58], has an unphysical[46] "orthogonal" component along the axis **W** in Fig. 4 (marked with **red** in the interface 'here and now' in Fig. 3), which will be totally ignored if we only work "intrinsically" with Gauss-Bonnet theorem. It does not exist as 'physical reality' (marked with **blue** in Fig. 3), yet is capable of altering the spacetime metric[55], and many people consider it "dark"[53].

I suggest that the axis **W** in Fig. 4 is related to atemporal *potential* reality pertaining to the "intermediate time" of a "free" photon "during" flight[22] (see above). It is luxonic reality[20], and is anything but "dark". Also, it should be capable of fixing the extensions of '1m' (Fig. 12) and 'two pint beer' (Fig. 10) by *actual* infinity[26]. But how?

Good question. Let's see first what we *cannot* use to solve the puzzle.

Firstly, the buildup of 'space' cannot be based on some "intuitively clear" but totally wrong ideas of *finite* chunks of matter[69] (Fig. 2), like in the definition of international second above, so that we can apply Baldy's Law 'some of it plus the rest of it is all of it' at the fundamental level of "that which has no part" (Euclid) and treat the atoms of

geometry as distinguishable denumerable apples separated by air and wrapped by a bag (Fig. 13), after which we sweep the garbage under the rug by jabberwockies[14] , like boundary set (Fig. 9), "many points", paracompact manifold (Wald[60]), Hausdorff space, compact space, second countable topology, and countably infinite set à la Chuck Norris.

Secondly, the alternative approach of seeking "intuitively clear" limit by actual infinity leads to treating the atom of geometry as "zero" viz. Eq. 1 above, which is also wrong.

In my opinion, the only solution is to apply the doctrine of trialism[6] and interpret the two sides of Eq. 1 above, *zero* or *infinite* (unphysical) and *finite* (physical world[69]) as **complementary**, like an Eskimo trying to understand the elephant's trunk[29].

Therefore I will introduce the idea of 'hyperimaginary element', denoted with $\mathbf{L_i}$, as *potential* gravitational reality (Eq. 2), and will postulate that the invariant spacetime interval, examined as 1m (Fig. 12) and 1min (Thomson's lamp), is being *assembled* along the axis **W** in Fig. 4 and Fig. 1 with hyperimaginary element $\mathbf{L_i}$, leading to 'space' and 'time' in *relative scale* spacetime. An observer at the length scale of tables and chairs (table 1m in Fig. 15) will see $\mathbf{L_i}$ being either "shrunk" to Plank length[35] (**MN** in Fig. 5) or "inflated" to *the* maximal spacelike hypersurface (**AB** in Fig. 5) in which the normal vector at *every* point is time-like (P. Chrusciel[19], p. 247).

Yet the observers with the size of Plank length[35] (seen as "the smallest" **MN**, Fig. 15) and with the size of maximal spacelike hypersurface (seen as "the largest" **AB**, Fig. 15) will have "the same" *relative* size within their opposite domains **as well**.

Who has the right 'one meter' and 'one second'? Wrong question. All observers along the entire length scale have *the same albeit altered* RS meter and RS second.

Perhaps the best way to explain the meaning of 'the same albeit altered' is with the river metaphor by Heraclitus. I will introduce two Platonic (Fig. 1) objects: (**i**) **r**ate of 'time flow', denoted with **R** and corresponding in the river metaphor to 'water/time per second'; **R** obtains numerical values along **y**-axis in Fig. 14, and (**ii**) relative **s**ize denoted with **S**, obtaining numerical values along **x**-axis in Fig. 14. A table with length 1m (Fig. 15) is located at $\mathbf{x} = \mathbf{y} = \mathbf{1}$ and at $-\mathbf{x} = -\mathbf{y} = -\mathbf{1}$ in Fig. 14 (extended **red** dots).

Now I postulate

$$\mathbf{RS} = \mathbf{1} \quad \text{(Eq. 2)}.$$

Relative to a table with length 1m, the size **S** of Plank length[35] **MN** (Fig. 5 and Fig. 15) is indeed *the smallest*, as $\mathbf{S_{MN}}$ (not shown in Fig. 14) tends asymptotically toward $\mathbf{x} = \mathbf{0}$. But according to Eq. 2, $\mathbf{R_{MN}}$ tends asymptotically toward $\mathbf{y} = \boldsymbol{\infty}$, which is interpreted as $\mathbf{R_{MN}}$-times *more* 'water/time per second' at Plank scale, producing maximal **inflation** of RS spacetime at Planck scale. Hence all objects with Plank length[35] **MN** (Fig. 5) will have at Planck scale 'the same albeit altered' size 1m. Yet relative to a table with length 1m, their size and Planck time is indeed *the smallest*. Ditto to the opposite case of *the largest* **AB** in Fig. 5 and Fig. 15: the value of $\mathbf{S_{AB}}$ (not shown in Fig. 14) tends asymptotically toward $\mathbf{x} = \boldsymbol{\infty}$, which is why **AB** is indeed *the largest* object but, because of the reciprocal value (Eq. 2) of $\mathbf{R_{AB}}$ tending asymptotically toward $\mathbf{y} = \mathbf{0}$, the

spacetime of **AB** is maximally **shrunk** to 'the same albeit altered' size 1m. And if we claim that the rate of 'water/time per second' at macroscopic length scale is 1s/s, 'the same albeit altered' 1s/s will be valid for **MN** and **AB** as well. It's all relative[63].

Back to the hyperimaginary element L_i : it is neither *finite* (Fig. 10) nor *zero* (Eq. 1), but 'something else'[59], *sit venia verbo*. Here we have to proceed with utmost caution, because such object may be beyond our comprehension. I will apply the doctrine of trialism[6] and interpret L_i as elephant's trunk[29], which Eskimos see it as "nose" (equivalent to quantum "particle"[29]), but only to the extent to which 'nose' is **finite**[69] reality possessing physical **footprint** placed in the irreversible **past** of the interface 'here and how' (Fig. 3). Hence we, as Eskimos endowed with Archimedean topology[69], can try to apply some sort of cognitive "discreteness" to understand what we picture as physicalized "nose" by frames-per-second (FPS) analogy — we can *imagine* that the invariant spacetime interval, shown as 1m (Fig. 12) and 1min (Thomson's lamp), is being *assembled* by L_i along the axis **W** in Fig. 4 and Fig. 1 in three ways: (**i**) as **90 fps**, producing the macroscopic world in which a table has RS length **1m** (Fig. 15), (**ii**) as **270 fps**, producing 3x "inflated" RS spacetime (**AB** in Fig. 15), and (**iii**) as **30 fps**, producing 3x "shrunk" RS spacetime (**MN** in Fig. 15). In their RS domains, however, the Heraclitean *flow* of time will be always 1s/s, and *their* RS "1m" and RS "1s" will be *indistinguishable*. However, relative to a macroscopic observer[69] in the middle between **AB** and **MN** (Fig. 15), **AB** will be **in fact** 3x larger and **MN** will be **in fact** 3x smaller as well: see Eq. **2** above. It's all relative[63].

Relative to a table with RS length 1m (Fig. 15) depicted with two **red** dots in Fig. 14, L_i is being shrunk to **MN** and inflated to **AB** (Fig. 15), depicted with the "running guys" in Fig. 5.

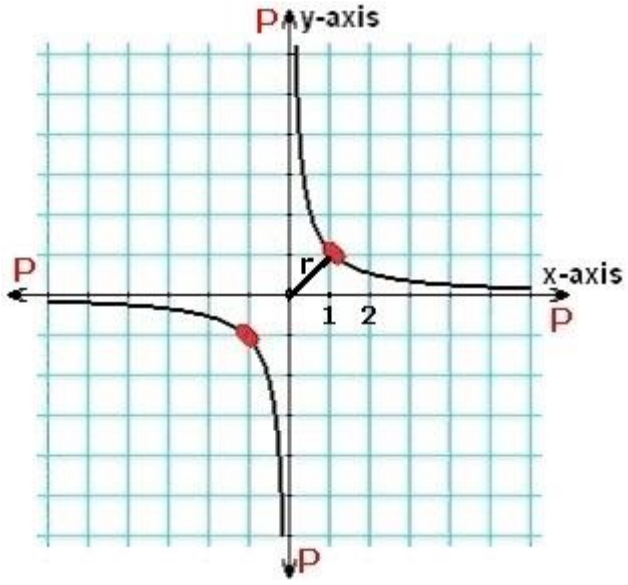


Fig. 14
Red dots : +/- x = +/- y = +/- **1**

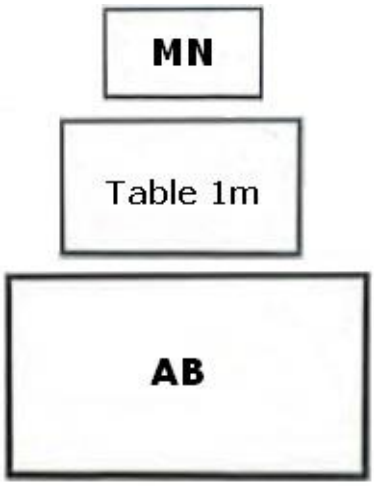


Fig. 15
Table 1m: **red** dots in Fig. 14

Fig. 14 shows the creation of RS spacetime (Eq. 2) by the hyperimaginary element L_i

taking non-zero values; **P** in Fig. 5 is only on **x** = **0** or **y** = **0**. **MN** (Planck length[35]) in Fig. 5 and Fig. 15 correspond to $\mathbf{x} \rightarrow 0$ and $\mathbf{L_i} \rightarrow \mathbf{P}$ in Fig. 14, leading to the "smallest" region of relative scale spacetime, while **AB** in Fig. 5 and Fig. 15 correspond to $\mathbf{x} \rightarrow \boldsymbol{\infty}$ and $\mathbf{L_i} \rightarrow \mathbf{P}$ in Fig. 14, leading to the "largest" region of RS spacetime. The inflation of RS spacetime between $\mathbf{x}_1 = 1$ and $\mathbf{x}_2 = 2$ in Fig. 14 resembles Hubble's law, but it is not linear and implies "accelerating universe". The interpretation of the negative (mirror) case in Fig. 14 is unclear; I suppose it is related to the sphere-torus transitions in Fig. 7, resembling the transformation of a rubber glove 'inside out', yielding 'left' vs. 'right' symmetry in the local mode of spacetime (parity inversion).

The Beginning (John 1:1) corresponds to $\mathbf{x} = \mathbf{y} \equiv \mathbf{0}$ in Fig. 14 and to Case **IV** in Table 1. Hence God is eternally residing "inside" every event 'here and now' (Luke 17:21).

Notice that a macroscopic observer in the middle between **MN** and **AB** (Fig. 15) cannot observe the *global* inflation or shrinking of the spacetime itself, but only its physical effects. In RS spacetime, there is no *absolute* length scale: see Sec. 1 above.

As to the origin of gravity (see above), it is interpreted as *local* inflation viz. *local* shrinking of $\mathbf{L_i}$. The latter removes the so-called non-baryonic "dark matter" and "supermassive black holes", while the former eliminates the mythical "dark energy"[53].

Regarding the gravitational rotation accompanying the global and local gravitational effects of $\mathbf{L_i}$, I suppose it is caused by "rotation" of the hyperimaginary element $\mathbf{L_i}$, leading also to 'spin' in the quantum world (see Sec. 5).

Last but not least, we do not treat 'the spacetime *itself*' as an ether which may exist independently (like a reference fluid[23]) from the physical stuff determining the spacetime, but as 'the grin of the Cheshire cat without the cat'[45], depicted in Fig. 16 below. The difference between the ether and the 'grin' is crucial, because it embodies the essence of General Relativity, as stressed by Albert Einstein on 29 November 1918[9].

Fig. 16

Fig. 17

Fig. 16 shows the non-localizable[4] atemporal *potential* gravitational reality along the axis **W** in Fig. 4, while Fig. 17 pertains to the localizable[29] or physical stuff placed in the right-hand side of Einstein's field equations[22]. Their mutual determination is depicted with the famous 'drawing hands' by Maurits Escher (Fig. 18).

Fig. 18

Which "hand" goes first? Matter (Fig. 17) of potential reality (Fig. 16)?

Wrong question. One cannot determine 'which goes first' with 'time as read with a clock'[58], as their non-linear[22] negotiation has been **already**-completed with fixing a **physical** footprint of the interface 'here and now', marked with **blue** in Fig. 3, in line with Leibniz' pre-established harmony[6]. Needless to say, the potential reality[29] in Fig. 16 springs from the *colorless* Noumenon (Fig. 8), which leads to Case **IV** in Table 1.

5. Discussion

Undoubtedly the theory of relative scale spacetime is still a work in progress, hindered firstly by the unclear hyperimaginary numbers (Paper **III**[1]) needed for the so-called *quantum sets* (Paper **II**[1]) briefly mentioned above. The process of building the theory very much resembles a jigsaw puzzle, in the sense that every piece snaps to its unique place effortlessly, but it also outlines a new blank section from the endless jigsaw puzzle: Nature is *coherent* (Sec. 1) and endless. Let me offer a snapshot of the current status of Relative Scale (RS) spacetime, based on the localization of matter and fields explained at **NB** above, leading to the Brain of the Universe (Table 1 and Fig. 8).

Imagine a 2-D section at the center of 3-D sphere in Euclidean space: all points of such flat circle (Fig. 9) belong to the 3-D sphere as well, yet the *physical* points belong only to the flat circle of 2-D "shadows" (Fig. 1). The *physical* points possess *dual* topology, being the very *interface* 'here and now' (Fig. 3) between the irreversible (**blue**) past and the potential (**red**) future spanned along an atemporal luxonix[20] axis **W** (Fig. 4) pertaining to the 3-D sphere, including the *dual* points of the circle. At every *physicalized* (**blue**) "component" of the *interface* 'here and now' (Fig. 3), the axis **W** is being completely **re**-eliminated – once-at-a-time[16,58] – to produce a perfect (Sic!) continuum of **re**-created, *physicalized* (cf. **NB** above) world of matter and fields (Fig. 17) cast in the irreversible (**blue**) past (Fig. 3). Hence 2-D Flatlanders will live **on** 2+1-D spacetime obtained by *assembling* their 2+1-D physicalized universe, endowed with a *perfect* 3-D continuum. Let's move now to 3-D Flatlanders with brains[21].

1. The alleged 'point' in point-set topology is not a denumerable "apple" (Fig. 13) but *spacetime interface* endowed with internal structure and **dual** topology (Fig. 3): its (**blue**) physical "footprint" is complemented by *atemporal* potential reality (Fig. 16)

residing in the potential future[61] of the so-called biocausality[2], spanned along the atemporal luxonic[20] axis **W** in Fig. 4. The physical world[69] is *physicalized* world (Fig. 1), ranging from the smallest (**MN**) to the largest (**AB**) spacetime domains (Fig. 15). The latter are endowed with Finite Infinity (Fig. 5) presenting two *complementary* presentations of 'size' and 'duration' in RS spacetime: both *finite* (Fig. 10 and the ark **APB** in Fig. 4) and *infinite* (along **W** in Fig. 4), in the sense that 'potential reality' (Sec. 2) is *indefinable* due to the absence of *metric*. Hence Finite Infinity is also **dual** topological object keeping its complementary presentations *en bloc*, which makes it totally incomprehensible with human cognition[57]. In the next Paper II[1] (in preparation), I will elaborate on the doctrine of trialism[6] applicable to ontologically dual objects (every quantum-gravitational object is both "particle" and "wave", resembling elephant's trunk[29]) by suggesting a new zero-valued logic **YAIN** (from **Y**es **A**nd ne**IN**).

Regarding **Finite Infinity** (Fig. 5), notice that the two types of infinity[43], potential and actual/completed[26], are complementary: the former is always in *motion* and **never** stops, while the latter is always *completed* and **stops** at the limit. If Nature were using only the unending potential infinity (PI), in which every step toward the infinity is the necessary and sufficient condition for the *next* step, there will be two alternatives: either (i) PI can reach the limit or (ii) PI cannot reach it. Case (i) means that PI will surpass the limit and move further *ad infinitum*, while case (ii) means that the limit does not exist. In fact, in both cases (i) and (ii) the limit cannot exist. If Nature were using only the actual or *completed* infinity (CI), which always **stops** at the limit, there are two alternatives: either (iii) CI can reach the limit and then **stops** there or (iv) CI cannot reach it and can **never** stop there. Case (iii) means that Nature is finite but there is something *beyond* it (Fig. 10), whereas case (iv) contradicts the definition of CI as "a totality of things which exists **all at once**"[26]. Only the *union* of PI and CI is perfect: thanks to PI, Nature is *endless* and open to brand new events still in 'the unknown unknown', while CI ensures that the limit *can and will* be reached, thanks to which there are *finite* things in Nature[69], such as 1m and 1min (see above).

2. The atemporal potential reality (Fig. 16), dubbed causal field, leads to physical theology (Table 1) in which God is presented as the union of two sets, colored and *colorless* (Fig. 8), viz. to the incomprehensible 'set of all sets' (if any) endowed with the self-action of Unmoved Mover.

3. To explain the creation of relative scale spacetime from 'something else'[59], a pre-geometric plenum has been suggested, dubbed 'hyperimaginary element' (Eq. 2) and endowed with "torsion" (Fig. 20) accompanying the two types of gravity in RS spacetime — force-free gravitational attraction (local "shrinking" of spacetime) and force-free gravitational repulsion (local "inflation" of spacetime). Notice that RS spacetime is *wave-like* theory and does not employ tensors nor spacetime curvature[44]: the quantum-gravitational "wave" is presented as *causal field* residing in the potential **future**, being an **intact**[29] potential reality.

In my (perhaps biased) opinion, this is the only way to explain the genidentity of particles[62,63,64] and the "conservation"[16] of energy[13] as **re**-created "shadows" (Sec. 2), from proton's mass[64] to vacuum energy[10,34], including gamma-ray bursts.

To those interested in the nature of gravity and how its energy can be "conserved"[13,70], watch an eloquent explanation by Paul Steinhardt[16] at YouTube (2 min, 6.7MB) or at this http URL, 01:37 - 02:00 from the timeline: the energy "conservation", in symbolic

terms, is like **0** = (**9**) + (-**9**). Replace **0** (zero) with the *colorless* Noumenon depicted in Fig. 8 and you will have *creatio ex nihilo*, meaning 'out of nothing comes **everything**'. The "positive" and "negative" objects in the right-hand side of the symbolic equation above are **squared**, so the equation of inflation energy is like $\mathbf{0} = \mathbf{3}^2 + (\mathbf{3i})^2$.

Regarding the "negative" component made of imaginary mass, providing an infinite pool of "dark energy"[53,70], see the tachyonic world with inverted spacetime basis in M. Tegmark[20]. As to the "positive" or *physical* component, check out an example from A. Dolgov [64]. The left-hand side of the equation above is not actually "zero", because it refers to *light vacuum* presented with squared hyperimaginary unit, $w^2 = \mathbf{0}$. Hence the three types of mass, positive, negative, and imaginary, are presented in the right-hand side of a new *evolution* (not "conservation") equation as

$$w^2 = |\mathbf{m}|^2 + |\mathbf{m_i}|^2 \quad \text{(Eq. 3)}.$$

In words, Eq. 3 means 'out of light vacuum comes **everything**'. Both the omnipresent light vacuum *and* the right-hand side of Eq. 3 are **always** residing in the causal field "before the light" (Fig. 19 and Fig. 20), so the *physicalizable* world[29] "sees **nothing**" **until**[66] it becomes explicated as physicalized "shadows" (Fig. 1) cast in the irreversible past (Fig. 3) with *positive* energy only[16], being *assembled* along **W** in Fig. 4 (depicted with the **red** point **W** in Fig. 19 and with **x**,**y** = **0** in Fig. 14) as *perfect* continuum with *perfect* Lorentz invariance and 'no evidence of gravity'[16] — once-at-a-time, as read with a physical clock.

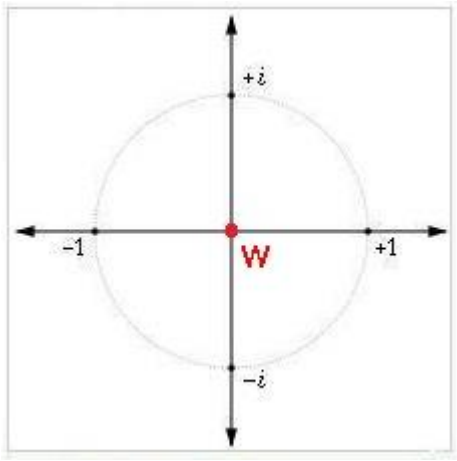


Fig. 19
Adopted from Wikipedia

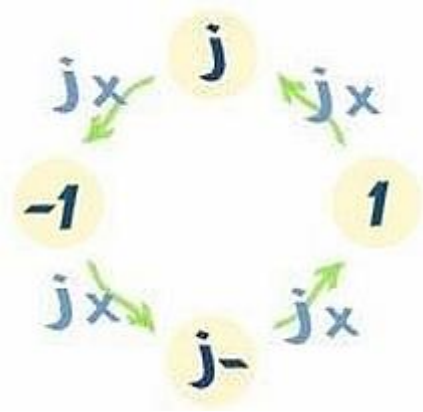


Fig. 20
Adopted from R. Pierce[71]

Fig. 19 and Fig. 14 refer to the atemporal luxonic[20] time of the causal field, in which the sphere-torus transitions are **trespassing** God (John 1:1 & Luke 17:21) at absolute infinity depicted with horizontal line in Fig. 7 matching the *interface* 'here and how' in Fig. 3. The latter is denoted with **W** in Fig. 19 and with the center of Fig. 14, **x**,**y** = **0**. Metaphorically, Fig. 19 and Fig. 14 resemble a water lily with four fully opened leaves, two real and two imaginary, and the instant at which the four leaves are fully closed or "squared" leads to Eq. 3 above, which may resemble the 'Breathing of the Universe' (Qi Gong): *inhaling* (opened leaves, Fig. 19) and *exhaling* (closed or "squared" leaves, see Eq. 3 above). Also, the water lily has two additional *hyperimaginary* leaves

orthogonal to the plane of Fig. 19, with equal size and footprint on **W**, shown with **WP** and **P0** in Fig. 6 (not scaled). They are also "breathing" by $w \leftrightarrow w^2$ (see Eq. 3 above), hence the square root of **w** is not "**zero**", and the orthogonal hyperimaginary components along **W** (**WP** and **P0**) participate in an overall hyperimaginary "rotation" of the causal field. To explain the hyperimaginary sphere "at south" (Fig. 7), see its radius **r** in Fig. 14, defined with $\mathbf{r}^2 = \mathbf{x}^2 + \mathbf{y}^2$, and try to picture its hyperimaginary radius **r** = **WP** = **P0** (not scaled in Fig. 6). At the end of the day (Paper **III**[1]), I hope to present the causal field "before the light", in such way that it "would be able to see all six sides of an opaque box simultaneously, and in fact, what is inside the box **at the same time**, just as we can see the interior of a square on a piece of paper. It would be able to see all points in 3-dimensional space **simultaneously**, including the inner structure of solid objects and things obscured from our three-dimensional viewpoint" (Wikipedia). To picture the hyperimaginary "view" on 4-D spacetime, imagine we are on the Moon and can see at all points from the *surface* of the Earth (two-dimensional sphere) **simultaneously**, and at *the same instant* we are at the center of the Earth **as well**, and can see *the same* points from its 2-D surface but from **inside-out**, like turning a rubber glove inside-out, pictured with a circle in Fig. 21: left glove ↔ right glove. Now all we have to do is to move to 3-D hypersurface and "look" at the physical 4-D spacetime from the dimensionless causal field, which keeps the *idea* of a tree and the *idea* of a mountain, as stated earlier, in terms of an **intact** Schrödinger cat[29].

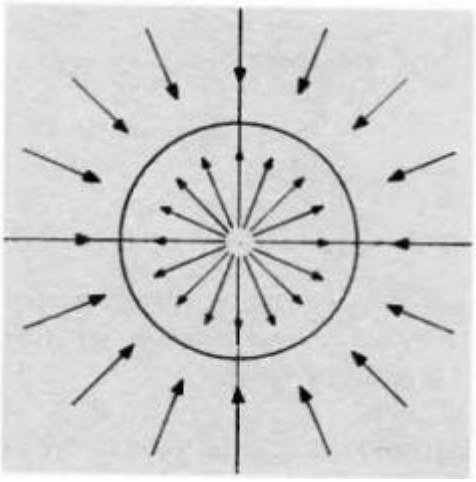


Fig. 21, adopted from Mark Armstrong[72]

To wrap up the discussion of Eq. 3, let me stress that it is still a symbolic equation, like the symbolic Einstein's field equation **G**(geometry) = **T**(matter)[73], hence the *specific* interpretation of Fig. 19 and Fig. 20 above may be wrong, which may later suggest the correct mathematical presentation, much like with the first effort by Einstein to suggest its field equation (Wald[60], p. 72), which was later corrected by Tullio Levi-Civita[74]. I will be happy if the reader can suggest an alternative theory and proves relative scale spacetime wrong, because I wouldn't need to wrestle with some hyperimaginary numbers based on still unknown operators applicable to unknown sphere-torus transitions trespassing absolute infinity (Fig. 7). This is the reason for shelving Paper **III** to 2018[1], hoping that meanwhile we can unravel some brand new mathematical ideas, which perhaps are still in the realm of 'the unknown unknown'.

Perhaps we just have to pick up an avenue of research and explore it: run it and see what happens. Besides, as Christopher Columbus remarked, if we didn't sail out west into the Atlantic to seek new route to India, how could have we discovered America?

The next Paper **II**[1] (in preparation) will elaborate on Eq. 3 and introduce biocausality[2] by applying Ulric Neisser's cognitive cycle[61] to the Brain of the Universe, and will suggest novel topological properties of spacetime, resulting from the causal field. The postulated hyperimaginary "rotation" of the causal field is supposed to include 'spin UP' (Fig. 22) and 'spin DOWN' (Fig. 23), referring to what Wolfgang Pauli dubbed '*eine eigentümliche, klassisch nicht beschreibbare Art von Zweideutigkeit*'. In Fig. 22, the fingers of the *right* hand curl counter-clockwise; the thumb (not shown) points UP, while in Fig. 23 the fingers of the *right* hand curl clockwise; the thumb (not shown) points DOWN. Nature should have two "hands", right and left (Fig. 14 and Fig. 19), also as '*klassisch nicht beschreibbare Art von Zweideutigkeit*'. The unphysical axis of quantum spin minus its physical basis is the axis of right/left thumbs, presenting hyperimaginary degrees of freedom of the causal field. What we call 'gravity' (Fig. 24) is exclusively macroscopic phenomenon (there is no gravity in the quantum world), interpreted as force-free Coriolis effect outlining a physical axis of galaxy rotation (David Wittman), yet such axis is not related to some *physical* rotor that could twirl a galaxy, nor to some *physical* but "dark" (whatever) in its center.

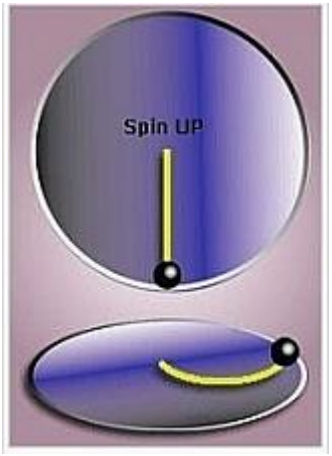


Fig. 22

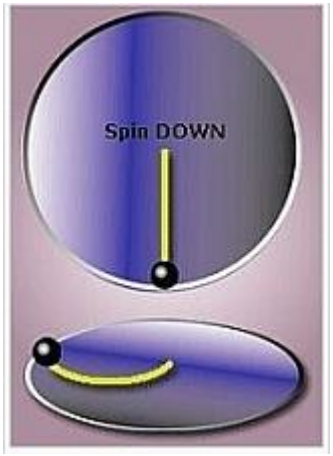


Fig. 23

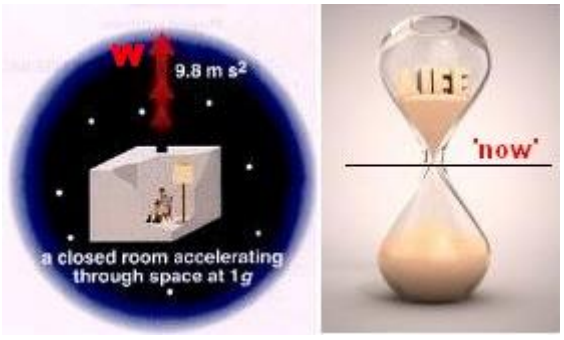


Fig. 24

The general idea in Paper **II**[1] is to present the **physical** component of the interface 'here and now' (Fig. 3 and Fig. 1 below) as a timeless "shadow" of the Universe: a CPT-invariant quantum world in "small" RS spacetime (Fig. 14), and a macroscopic world in "large" RS spacetime with 'no evidence of gravity'[16]. The infinitesimal increment of time, denoted with **dt** , is omnidirectional in space, as its "direction" matches the **red** arrow **W** in Fig. 24 above. The state of free fall[75] corresponds to the atemporal luxonic[20] "time" along axis **W** in Fig. 24, Fig. 4, and Fig. 6, called 'global mode of spacetime' and attributed to the **intact** quantum-gravitational world[29]. It may also be crucially important for spacetime engineering[63], provided that the human brain can *entangle* its UNspeakable **intact** potential state (details in Paper **II**[1]) with that of the Brain of the Universe (Cases **I**-**III** in Table 1) by a topological "bridge", presented with its qualia[21]. Then we could perhaps create a new associative link in both brains, which will be kept in their common long-term memory indefinitely, much like learning to ride a bike. If the Brain of the Universe can twirl a galaxy, it should easily cope with the rotor of power stations, providing *perfectly* clean and unlimited energy source[24].

The local "shrinking" of RS spacetime (see above) leads to irregular clumsy structures, while the local "inflation" of RS spacetime leads to *smooth* "dark energy"[53]. The two force-free manifestations of gravity should be in tug-of-war *dynamic* equilibrium to facilitate formation of structures. More in the excerpt from Paper **II**[1] below.

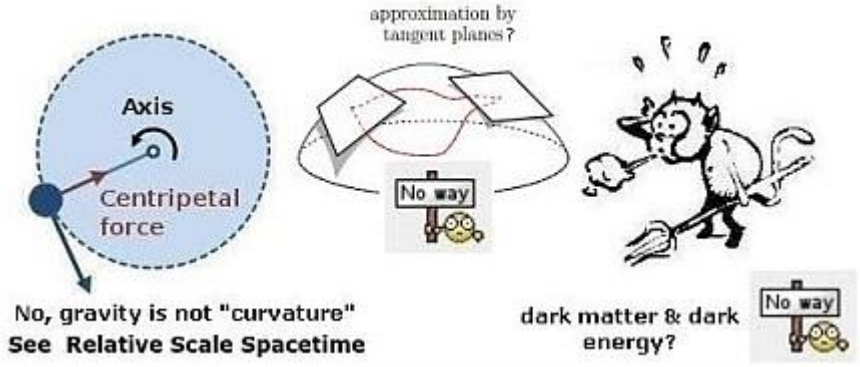
> I have again perpetrated something relating to the theory of gravitation that might endanger me of being committed to a madhouse. (*Ich habe wieder etwas verbrochen in der Gravitationstheorie, was mich ein wenig in Gefahr bringt, in ein Tollhaus interniert zu werden.*)
>
> Albert Einstein, letter to Paul Ehrenfest, 4 February 1917

Potential Reality II: Quantum Gravity

D. Chakalov
35A Sutherland St
London SW1V 4JU, U.K.
Website chakalov.net

1. Introduction

In the previous paper (Paper **I**[1], refs **6**-**9** and **29**), I elaborated on Thomson's lamp paradox and suggested the rule for localization of quantum-gravitational Cheshire cats, to resolve *the* most widely known public secret in theoretical physics shown at this http URL and summarized with the drawing below.



The *grin* of the Cheshire cat (Fig. 16 in Paper **I**) is like the mysterious cat Macavity (T.S. Eliot): it is **not** physically observable, in the sense that every time the "chained observers" (Plato) look at Macavity[66], it has *already* (Sic!) disappeared. We may call Macavity "vacuum", but it is actually *light vacuum* (Eq. 3 in Paper **I**) from which quantum-gravitational cats emerge, like the *physical* states of Thomson's lamp in Dirac notation, either |on> or |off>, leaving the lamp *per se* **intact**[29]. Let me explain.

Consider pattern recognition and imagine a set of apples with different colors on a table in front of you, and divide them as follows: place all *strictly* red apples to the left, and all *strictly* yellow apples to the right. Now you can suggest the locations of all apples that are *partly* red and *partly* yellow, and place them between the two subsets of apples, as well as ignore all green and greenish apples, because they do not fit there. Easy, because you can *see* their colors. But what if you "see" with your **mind** only (pp. 7-8 in HBP.pdf), and instead of choosing specific color you choose specific *meaning*? No problem; check out the meaning of four sayings on p. 2 in HBP.pdf. Every human brain can estimate the "color" (meaning) of such different "apples" (sayings), although the underlying cognitive-and-quantum vacuum is **UN**speakable. Physically, it is like Macavity[66]. I call this UNspeakable **intact** potential state of the brain 'potential reality' (Fig. 5 and Fig. 16 in Paper **I**). And since the human brain works with 'potential reality', the Brain of the Universe may be doing the same, and perhaps *much* better. Let's begin with the human brain.

The human cognition is based on (quantum) sets; therefore, we cannot define 'set' with itself (it will be like defining 'heat' with some tiny little and very hot particles). For example, the very fact that we can think of 'everything that is On' shows the sets of ordinals[67]. But the set itself is an **indefinable** 'totality of things' (Cantor), coupled with what this 'totality of things' is **not**: $\mathbf{A} \cup \neg \mathbf{A}$. In fact, we can think *iff* we can form a set **A** defined with respect to 'what is not-**A**', $\neg \mathbf{A}$. It's all relative. The cognitive limits of our relational cognition are shown with the ultimate 'set of all sets' (if any), which is indefinable and undecidable to humans. But the Brain of the Universe may not have such limitations, as it includes what we could *only* call 'Noumenon': see the 'eye of the Universe' in Fig. 8 in Paper **I**.

In this Paper **II**[1], I will apply Neisser's cognitive cycle to the quantum-gravitational *potential* reality, leading to self-action of the Brain of the Universe, performed along the *atemporal* axis **W** , shown in Fig. 1 and Fig. 4 in Paper **I**. Namely, I will elaborate on Neisser's cognitive cycle by borrowing Escher's 'drawing hands', inserting there the *interface* 'here and now' (Fig. 1 below), shown previously in Fig. 3 in Paper **I**[1].

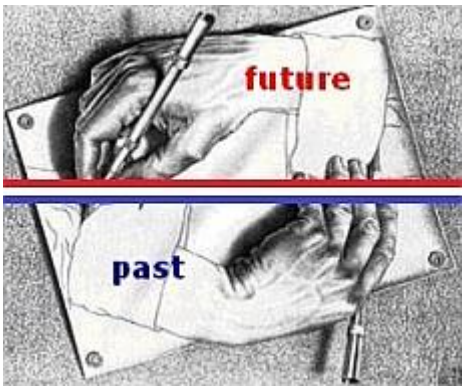


Fig. 1
Time orientability (P. Chrusciel, p. 247)

Obviously, one cannot explain the non-linnear[68] negotiation of the two hands with what physicists call 'time as read with a clock': at any instant from the *physical* time (local mode of spacetime), their *atemporal* negotiation has been *already* (see Macavity above) completed, once-at-a-time. Subsequently, the set of **intact**[29] *potential* states (Fig. 16 in Paper **I**) of all physical systems is dubbed 'causal field' (global mode of spacetime). In Sec. 2 below, a new form of retarded relativistic causality, called 'biocausality', will be introduced along an **Arrow of Space**: the Heraclitean flow of time is modeled as 'change *of* space' along the *atemporal* axis **W** , shown in Fig. 1 and Fig. 4 in Paper **I** (global mode of spacetime), while 'change *in* space' pertains to the physical or coordinate 'time as read with a clock' (local mode of spacetime). Hence the rule 'think globally, act locally' is attributed to Einstein's 'God's thoughts'.

What matters here is that the human brain performs self-action: the brain — **not** its mind — acts *on* itself, since it has *potential* state in its **future**, and *by* itself, being also physicalized object in its **past** (Fig. 1). Physically, we can observe only the physical "footprint" of the brain cast in the **past**, because brain's potential state is *physically* unobservable Macavity[66]. What if the Brain of the Universe can also perform self-action, by acting on its own quantum-gravitational *potential* state placed in its **future** (Fig. 1)? If true, we may uncover the hyperimaginary numbers and develop *the* theory of quantum gravity based on quantum sets (Sec. 2). Let's go back to Ancient Greece.

Regarding the paradoxes of motion (Eq. 1 in Paper **I**), let me comment on what Euclid called "that which has no part": the endpoint of producing a *perfectly* smooth circle.

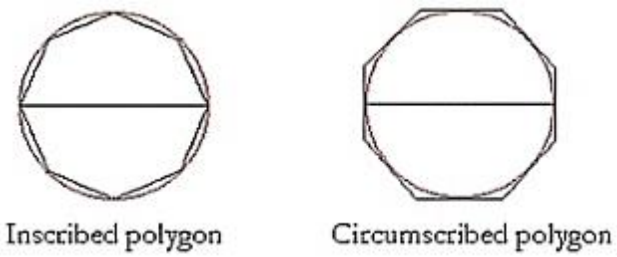


Fig. 2

It is the 'atom of geometry', and its origin can be explained with the (ε, δ)-definition of limit (Fig. 10 and Fig. 12 in Paper **I**) used to derive the circumference of a circle. If we picture the sides of inscribed and circumscribed polygons (Fig. 2) as Thomson's lamp, the obvious 'limit' is the *atom of geometry* called 'point' at which there is no 'lamp' anymore. Namely, the "lamp" is the potential Platonic image of an **intact** 'lamp *per se*', residing in the "dark strips" shown previously in Fig. 2 in Paper **I**. It is needed to explain how biocausality is being "transmitted forward in time through a sequence of instants, in each of which motion does **not** exist"[76] and must **not** exist, or else we cannot observer 'time as change' (Fig. 1) but a timeless "block universe".

Here I must stress that contemporary mathematicians are still trying very hard to ignore the paradoxes of Dichotomy[76] by "identifying" the atom of geometry (Fig. 1) with a "number". As Bryan Bunch[77] explained,

> The essential problems to solve are those concerned with limits and continuity. When Newton and Leibniz developed the calculus, their explanations of why their new methods worked did not solve these problems. Consequently, their ideas were attacked for being full of paradoxes. A major problem was that a quantity was very close to zero, but not zero, during the first part of the operation; then it became zero at the end. When you "took the limit," as folks say today, quantities that existed before suddenly ceased to exist. One critic, Bishop George Berkeley, called the result the "ghosts of departed quantities."
>
> In the nineteenth century, A. L. Cauchy and Karl Weierstrass resolved these paradoxes by defining them away. That is, the definitions of limit and continuity were given in such a way that the startling change from not-zero to zero was avoided. In doing so, they came down firmly on the side of a point having no size — just a location — in mathematics. Furthermore, by identifying points and numbers as the same thing mathematically, geometric intuition could be eliminated, since it was possible that the geometric concept of a point could mislead the mathematician. In fact, Weierstrass and others defined curves or sets of points that defied geometric intuition. Numbers were safer.

Only numbers are not "safer" but 'half wrong' (or 'half correct', if you prefer), as they refer only to the *physicalized* world in the irreversible past shown in Fig. 1, which is why we need hyperimaginary numbers (Paper **III**[1]) – not some "transfinite numbers" among which the academic scholars choose "the smallest" one, denoted with Aleph 0: the expression "many points" is an **oxymoron**, as the continuum of points does **not** possess Archimedean topology[69] and therefore cannot be counted[78] à la Chuck Norris. The final **stop**-point at "zero sides" (Fig. 2 above), obtained with *completed* infinity (see Fig. 10 and the tunnel analogy in Paper **I**), and the final **stop**-point at the multiplicative-inverse case "infinitely large" are shown in the left-hand side of Eq. **1** in Paper **I**. The entire *physicalized* world, endowed with Archimedean topology[69], is wrapped at the level of spacetime *manifold* by its *potential* state: an UNspeakabe **intact**[29] potential reality (Fig. 1) "before the light", which certainly looks like "zero" or "infinitely large" (Fig. 5 in Paper **I**), but only to the *physicalized* world with Archimedean topology[69], depending on the direction we look at it. But in fact, it is ONE entity: see Table 1 in Paper **I**.

Mathematicians postulate that the number line were made of points and nothing but points, as seen in Fig. 2 above, and then *deeply* believe that "every point on a straight

line corresponds to a single real number, and vice versa" (Wikipedia). But the latter statement is 'half wrong' (or 'half correct', if you prefer), because every point on a straight line is defined by an "empty set" **as well**, yet this "empty set" does not exist at the point from the number line (Fig. 3): see the final **stop**-point, marked at the 'limit' with **1**, in Fig. 12 in Paper **I**, and notice that the crucial object $R_{\infty} = \emptyset$ is conspicuously missing. Why? Because this crucial "empty set" $\emptyset$ presents the *nullified* axis **W** (Fig. 1 and Fig. 3 in Paper **I**), which does **not** anymore exist in the irreversible past shown in Fig. 1. Why not? Because it is ontologically **undecidable** (Bunch[77], pp. 195-196). The "empty set" $\emptyset$ exists only and exclusively only in the *potential* future marked with **red** in Fig. 1, as UNspeakable **intact**[29] potential reality (recall the exercise with apples/meanings above) with *hyperimaginary* values ranging in the **closed** interval **[0, ∞]**, which leads at the end of the day to physical theology, as explained in Table 1 in Paper **I**.

To sum up, the *hypernumber line* (not shown in Fig. 3 below), as demonstrated in Fig. 2 above, is made of 'hypernumber points', and every single hypernumber point from it, also dubbed 'atom of geometry' (Fig. 1), matches hyperimaginary number. Physically, every hyperimaginary number is being "collapsed" on its **physical** footprint (Fig. 1), producing uncountably-infinite numbers constituting the real number line (Fig. 3).

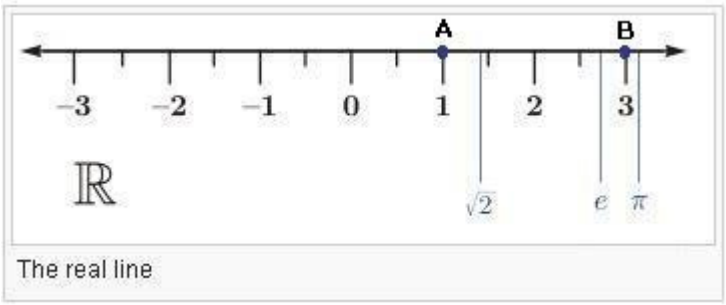


Fig. 3, adopted from Wikipedia

It is impossible in principle to map hyperimaginary numbers to *any* numbers shown in Fig. 3, which may create the *illusion* (Ed Nelson[79]) that actual/completed infinity does not exist. Yes it does exist, but it belongs to a *different* world described by Plato, which exists as ONE entity governed exclusively by actual or *completed* infinity, does not possess Archimedean topology[69], hence cannot be 'counted'. On the other hand, the *physical* world at the length scale of tables and chairs is 'countable'[79] and operates exclusively with *potential* infinity, therefore it can only *approach* the Platonic world dubbed here 'potential reality' *asymptotically*, 'as closely as desired'. The separation of these two worlds is made by the *interface* 'here and now' shown in Fig. 1 above. Without such separation, we will reach total nonsense: see Eq. 1 in Paper **I**.

Notice that the real points from the real line (Fig. 3) cannot *determine* the irrational "numbers". Consider a line segment uniquely determined by endpoints **A** = 1 and **B** = 3 (Fig. 3), at which we attach real numbers: **AB** identifies 'the one and only' real point **C** (not shown), separating **AB** by Golden Ratio. The real point **C** does exist, yet cannot be "numerized" by infinite descent, as **C** is rooted on **indefinitely-slipping** (Sic!) irrational number(s). Therefore a Dedekind Cut at **C** cannot be *actually* reached even with transcendental (non-algebraic) numbers, because both the irrational number at **C** and

all real numbers at every point from the real number line, **A** and **B** included (Fig. 3), are ontologically **undecidable** (Bunch[77], pp. 195-196). It does **not** matter that we can *see* some "exact" numbers attached to **A** and **B**, but not to **C**. Nature works with hypernumber points (Fig. 1), not with the numbers from the analytic number theory.

NB: The hyperimaginary numbers (Fig. 1) are "lurking" under **all** *real* points from the real number line (Fig. 3) *and* under **all** transcendental numbers (not shown), by means of an "empty set" **Ø** . Not surprisingly, the irrational numbers cannot have decimal presentation, which makes Cantor's diagonal argument invalid[79], and the academic scholars are back in murky waters: counting[79] on **non**-Archimedean topology is absurd.

To understand the inherent structure and **dual** (Sic!) topology of the hypernumber point (Fig. 1), check out the Flatland analogy in Sec. 5 of Paper **I** and keep in mind that the so-called causal field is not *res cogitans* nor *res extensa* [69] (matter and fields) but an **intact**[29] *potential* reality residing in the potential **future** of every hypernumber point "before the light", shown in Fig. 1. It also refers to *completed* or *actual* infinity, explained by David Hilbert as "a totality of things which exists all at once", and to the definition of 'set' by Georg Cantor as 'any gathering-together (*Zusammenfassung*) of determined and well-distinguished objects into a **whole** (*zu einem Ganzen*)'.

As explained in Paper **I**, every 'set' is quantum set, and the question addressed below is whether the Brain of the Universe can be explained as the *union* of *colored* reality and *colorless* **non**-reality, shown in Fig. 8 in Paper **I**. Obviously, 'the set of all sets' (if any) is incomprehensible to human cognition, and all statements regarding the qualia (if any) from the Brain of the Universe, such as Universal Mind and The Holy Trinity, are considered absolutely undecidable and will not be discussed. We all will find out the answers, sooner or later (better latter!).

2. Quantum Sets

Have you seen the changing colors of an octopus? It doesn't have *intrinsic* color. It is color*less*, yet can be *colorized* with every color. Pick any color of the octopus and ask yourself, 'is this the *true* color of the octopus?' **YAIN** (**Y**es **A**nd ne**IN**). *Yes*, because every physical color is produced by the unphysical *colorless* octopus, as explained by Plato. *Nein*, because the colorless octopus does not have intrinsic color. Now think of the *set* of its physical colors: it is a *quantum set* produced by the *unphysical* **intact**[29] *colorless* octopus, which is not a member of its own 'set of colors', because has no intrinsic color whatsoever: the *colorless* octopus cannot *in principle* possess any color, neither before nor after we measure it (Schrödinger), just like the UNspeakable "color" or 'meaning' in the exercise above. Now replace the *colorless* octopus with the so-called causal field, and recall Case **II** in Table 1 from Paper **I**. For example, in life sciences, the causal field can bootstrap thousands of fish into a school of fish, in such way that every (quasi) local fish communicates via the causal field with the entire school of fish by the rule 'think globally, act locally'.

This manifestation of the causal field is known as *wholeness*[80], and it can correlate trillions of synapses in the human brain as well. In the quantum-gravitational world, the causal field introduces the same rule 'think globally, act locally', which makes the quantum "particles" **flexible**[29], as their *physicalized* localization is *already* (recall Macavity) pre-correlated with 'the rest of the universe' ("school of fish"). The same

rule is fixing the gravitational energy density of every (quasi) local "fish". The list goes on and on, and all these instances of *wholeness*[80] are modeled with *quantum sets*.

Let me begin with *the* most widely known, ever since 1911, public secret in theoretical physics, hindering quantum gravity (Wald[60], p. 382): localization. I will examine the crux of Kochen-Specker Theorem[85] (recall the *colorless* octopus) and explain why it is **not** some "complement to Bell's theorem", as many people believe. To explain how quantum sets are implemented in biocausality, I will refer to the main idea in Hoyle-Narlikar Cosmology[81] (Fig. 4), comparing it to Fig. 5 below. Then in Sec. **3** I will apply biocausality to Einstein's General Relativity.

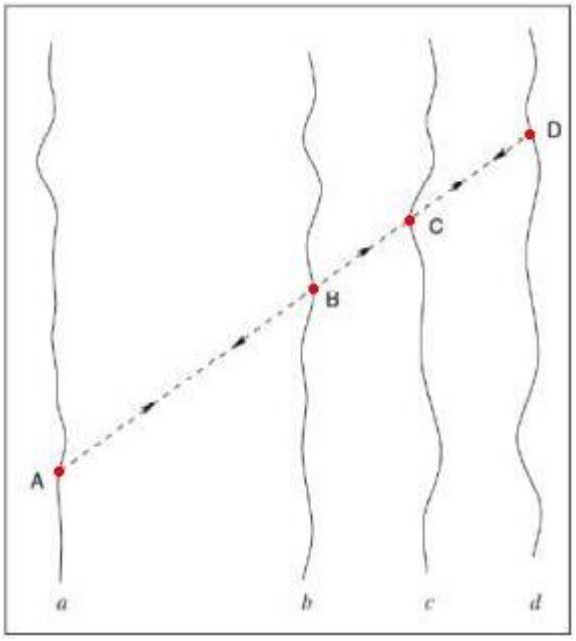


Fig. 4, adopted from J.V. Narlikar[81]

Explanation by J.V. Narlikar[81]: "A retarded signal (shown by dotted line) leaving point A on the world line of 'a' hits particles b,c,d,... at points B,C,D, ... at later times. Their advanced response returns to A along **the same** dotted track, no matter how far these particles are from 'a'. Thus even the remote parts of the universe generate instantaneous responses to the retarded disturbance leaving A. In short the response of the whole universe (Sic! – D.C.) cannot be ignored." Now compare Fig. 4 to Fig. 5.

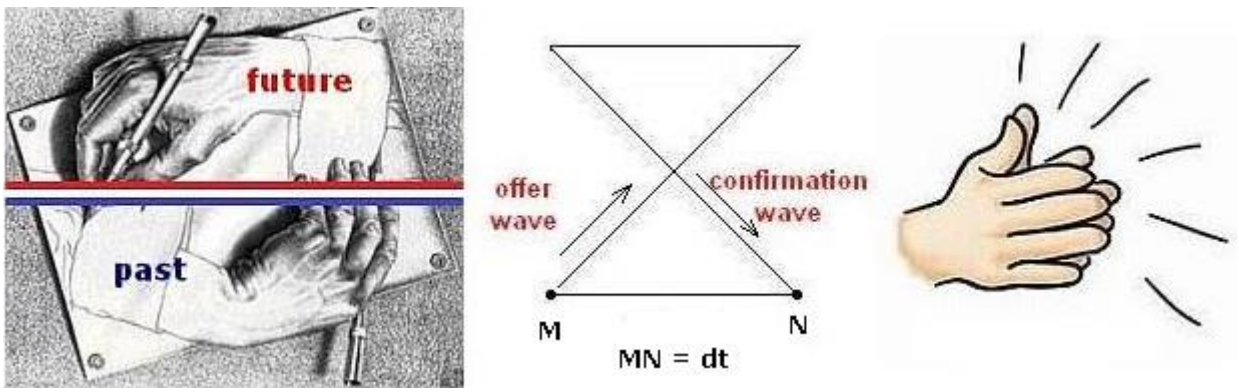


Fig. 5

NB: The event **A** in Fig. 4 is being *already*-completed (recall Macavity) in the *past* light cone of the same point **A**, like clapping hands (Fig. 5): the time "before" and "after" clapping is *atemporal*, like 'before the light' along **W**, due to the "speed" of light[22,83].

Unlike the advanced and retarded waves in Wheeler-Feynman absorber theory and in the transactional interpretation of quantum mechanics (TIQM), the waves in Fig. 5 present the *atemporal* causal field 'before the light' (not electromagnetic field) as "traveling" on null surfaces. The *infinitesimal* timelike displacement **dt** , denoted with **MN** in Fig. 5 and with **MN** in Fig. 5 in Paper **I**, is the only *physical* result from the *atemporal* negotiation between the offer and confirmation waves, like clapping hands — one-clap-at-a-time. The atemporal *transience* of time "happens" on null surfaces along the axis **W** in Fig. 1 and Fig. 6 in Paper **I**. It may have qualia[21], but it must not be *physically* observable, or else "the ether will come back!" (M. Montesinos[16]). The "consecutive" buildup by **re**-creation of spacetime within **MN** in Fig. 5 is being localized (present continuous) only in the past light cone (Fig. 1) — once-at-a-time — as local (physical) mode of spacetime endowed with relativity of simultaneity[82,83] and with Archimedean topology[69] of the *physicalized* world: a countable[79] *res extensa* spanned over an *objective* lapse **MN** of time[82]. To monitor the propagation of light "online", as it is happens along null surfaces[22,83], we would have to move "outside" the local mode of spacetime, in the "dark space" surrounding the elevator shown in Fig. 24 in Paper **I**, but then the Lorentzian ether will indeed "come back!" (M. Montesinos[16]) and the theory of relativity will be demolished. Which is why the *rate* of time, as the rate of water/time per second of the Heraclitean river, must remain *physically* unobservable[84]. It may have qualia[21] with which one could modulate the local *metric* of relative scale (RS) spacetime, but such highly speculative case of spacetime engineering[63] will not be discussed here.

Let me try to disentangle the bundle of issues related to *quantum sets*, and explain them thoroughly.

The idea of *atemporal* potential reality 'before the light' (recall Macavity and **NB** above), which has **zero** probability ($\mathbf{w^2 = 0}$) for direct observation and bootstraps quantum-gravitational systems into quantum sets (resembling a school of fish), goes back to Heisenberg[7] and to Schrödinger's article of 1935 and his letter to Einstein, dated 18 November 1950[8]. In the quantum world, the *atemporal* potential reality, resembling a *colorless* octopus, is physically unobservable, as *colorless* Kochen-Specker sphere (H. Granström[85]).

First, let's examine a case in which the *atemporal* potential reality is effectively absent. In the macroscopic world of *inanimate* systems, like tables, chairs, and computers (Case **I** in Table 1 in Paper **I**), it can be safely ignored. This case of 'reality' will be called '*objective* reality out there', and it has the following qualifications. For example, if you look at the Sun, you will see its state, which has been 'objective reality out there' 499s prior to your instant 'now' (Fig. 1) of observation, as recorded with your wristwatch. At *exactly the same* instant 'now', the Sun is an 'objective reality out there', which will be available to you for observation *after* 499s. Briefly, 'objective reality out there' is a **fact**, therefore it *either* 'is' *or* 'is not'.

As is well known, Quantum Theory does not operate with such **non**-contextual[85] '*objective* reality out there', but with *atemporal* potential reality 'out there'. But

where is its "location"? Along the *atemporal* luxonic axis **W**, but the latter has only an infinitesimal physical *footprint* in the **past** (Fig. 1), one-at-a-time, denoted with **dt** (Fig. 5), which is just a *physicalized* "shadow" (Fig. 1 in Paper **I**) that *either* 'is' *or* 'is not', and hence we can apply the Born rule to it: see Heisenberg[7] and Schrödinger's letter to Einstein, dated 18 November 1950[8].

In quantum gravity and life science (Case **II** in Table 1 in Paper **I**), the instant 'now' has non-trivial topological *structure* (Fig. 1): the event **A** in Fig. 4 is *already* (recall Macavity and **NB** above) *pre*-correlated[6] with all *potential* states belonging to **A**, **B**, **C**, and **D** by their common offer and confirmation "waves" (Fig. 5), leading to pre-correlated holomovement of all four "fish", like in a school of fish examined as 'quantum set'.

Hence we can apply Neisser's cognitive cycle[61] to the *physicalized*, **re**-created "shadow" of the Universe and model it as the Brain of the Universe: every interface 'here and now' (Fig. 1), shown as **MN** = **dt** in Fig. 5, is *both* fixed in its past as a 'fact' *and* **undecidable** in its *potential* future, like a quantum dough. Every transition to the **next** **dt** is a creative non-unitary *gain*, like the evolution of human Zygote, which makes the arrow of events in biocausality **irreversible**. If we apply biocausality to the Brain of the Universe backward in time, it will become **simpler** (not having "very low entropy state"[86]) due to losing its physical content by non-unitary *loss*, until it reaches its "prenatal" stage before the "inflation" of spacetime, at which the **W** boson and the **Z** boson[87] were still in the realm of 'the unknown unknown', as they still had no mass and could only patiently wait to be actualized later by the Noumenon (Fig. 8 in Paper **I**) with non-unitary *gain*, known also as *creatio ex nihilo*. In this sense, the future is **undecidable.** As Henry Ford put it, "Whether you believe you can do a thing or believe you can't, you are right."

Going back to Quantum Theory, check out Fig. 6 below, showing *the* most widely known, after Charles Wilson, public secret in theoretical physics, hindering quantum gravity (Wald[60], p. 382).

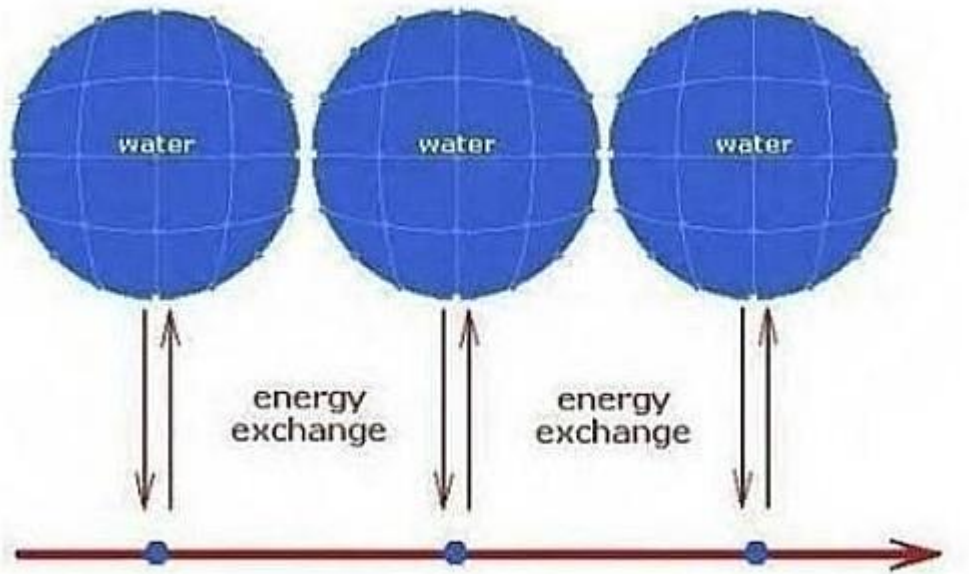


Fig. 6

Can you explain the emergence of visible track of water droplets in Wilson cloud chamber, made by **energy exchange** with a single quantum particle? Can you explain the invisible **red** quantum arrow (Hughes[85], Ch. 2.7)? If you can't[88], try the atemporal **intact** quantum state[29], which is neither "particle" nor "wave", does not "collapse" nor "decohere", and is not "uncertain" but *flexible*: God casts the die, not the dice (Einstein).

D. Chakalov, 8 November 2015, 23:59 GMT

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2. D. Chakalov, How To Bind Mind To Matter? Unpublished manuscript, January 1990. Abstract and explanatory note available at this http URL.

3. N. David Mermin, Is the moon there when nobody looks? Reality and the quantum theory. *Physics Today*, April 1985, pp. 38-47; Giancarlo Ghirardi, *Sneaking a Look at God's Cards: Unraveling the Mysteries of Quantum Mechanics*, Princeton University Press, 2007, p. 357 (the problem of macro-objectification).

4. Charles W. Misner, Kip S. Thorne, John A. Wheeler, *Gravitation*, W. H. Freeman, 1973, excerpts from p. 467 at this http URL and from p. 5 at this http URL; László B. Szabados, Quasi-Local Energy-Momentum and Angular Momentum in General Relativity (revised on 7 December 2012), *Living Rev. Relativity* 12 (2009), 4; excerpt from p. 31 at this http URL.

5. Wolfgang Rindler, *Relativity: Special, General, and Cosmological*, 2nd ed., Oxford University Press, 2006, p. 22.

6. The *atemporal* non-linnear[68] coupling (Fig. 18) of geometry (Fig. 16) to matter[9,22] strongly resembles the so-called mind-body problem, in which we also encounter two alleged alternatives: either the mind can act on brain's tissue, in which case it cannot be *res cogitans* but material stuff performing **work** (Sic!) on the brain and obeying Newton's third law, or cannot act on its brain, in which case it will be some ghost totally detached from its brain. The solution was put forward by Gottfried Wilhelm von Leibniz, by means of pre-established harmony of *res cogitans* (mind) and *res extensa* (body), which spring jointly from a *third* (the doctrine of **trialism**) entity viewed as their common source[2], the Universe as ONE (Luke 17:21) endowed with the self-action of the Unmoved Mover (Aristotle). Ever since The Beginning, the *physical* explications (*res extensa*) of the Universe have been perfectly fine-tuned and *pre*-correlated with all *future* (Sic!) requirements for life and cognition[21] (*res cogitans*), which supports what physicists call anthropic principle and rejects the mythical "multiverse".

7. Werner Heisenberg (winter 1955-1956), *Physics and Philosophy: The Revolution in Modern Science*, Prometheus Books, 1999, cf. p. 43 and pp. 155-156 at this http URL.

8. Erwin Schrödinger, Die gegenwärtige Situation in der Quantenmechanik, *Naturwissenschaften* **23**, S. 807-812; 823-828; 844-849 (1935). Translated by John D. Trimmer, available at this http URL. See also an excerpt from Schrödinger's letter to Einstein (Innsbruck, 18 November 1950), at this http URL.

9. *Albert Einstein, Philosopher-Scientist*, ed. by Paul A. Schilpp, Tudor Publishing Company, New York, 1951, p. 75. See also: A. Einstein, Dialog über Einwände gegen die Relativitätstheorie, *Naturwissenschaften*, 6(48), 697-702 (29. November 1918), S. 700: "Man kann deshalb weder sagen, das Gravitationsfeld an einer Stelle sei etwas Reales, noch es sei etwas bloß Fiktives." (…) "dem Gravitationsfeld an einer Stelle entspricht also noch nichts physikalisch Reales, wohl aber diesem Gravitationsfelde in Verbindung mit anderen Daten." ("One can say that the gravitational field at a point is neither real nor merely fictitious." (…) "nothing "physically real" corresponds to the gravitational field at a point, only to the gravitational field in conjunction with other data." Translated by A. Afriat and E. Caccese[24].)

10. M. P. Hobson, G. P. Efstathiou, A. N. Lasenby, *General Relativity: An Introduction for Physicists*, Cambridge University Press, 2006, cf. p. 187 at this http URL.

11. Michael Forger, Hartmann Römer, Currents and the Energy-Momentum Tensor in Classical Field Theory: A fresh look at an old problem, *Annals Phys.* 309 (2004) 306-389; arXiv:hep-th/0307199v1, cf. Eq. 228.

12. Erik Curiel, On Tensorial Concomitants and the Non-Existence of a Gravitational Stress-Energy Tensor, arXiv:0908.3322v3 [gr-qc].

13. Sir Hermann Bondi, Conservation and non-conservation in general relativity, *Proc. R. Soc. Lond.* A 427 (1990) 249-258, cf. p. 249 at this http URL; Hans C. Ohanian, The Energy-Momentum Tensor in General Relativity and in Alternative Theories of Gravitation, and the Gravitational vs. Inertial Mass, arXiv:1010.5557v2 [gr-qc], cf. p. 3 at this http URL; T. Padmanabhan, *Gravitation: Foundations and Frontiers*, Cambridge University Press, 2000, cf. pp. 211-213 at this http URL. To quote from Wikipedia (accessed on 30 September 2015), "in fact, it turns out to be impossible to find a general definition for a system's total mass (or energy). The main reason for this is that "gravitational field energy" is not a part of the energy–momentum tensor; instead, what might be identified as the contribution of the gravitational field to a total energy is part of the Einstein tensor on the **other side** of Einstein's equation (and, as such, a consequence of these equations' non-linearity)."

14. Demetrios Christodoulou, Mathematical problems of general relativity I. *Eur. Math. Soc.*, February 2008, Sec. 3.1, p. 35, Definition 32 available at this http URL; more mathematical jabberwockies in Fig. 9 and at http URLs here, here, and here.

15. Kurt Gödel, What is Cantor's Continuum Problem? *The American Mathematical Monthly*, **54** (1947) 515-525, cf. p. 515 at this http URL.

16. Paul J. Steinhardt, Inflationary cosmology on trial. Talk at Vanderbilt University,

March 17, 2011; see an excerpt (Steinhardt.mp4, 2 min, 6.7MB) at YouTube or at this http URL. Merced Montesinos, The double role of Einstein's equations: as equations of motion and as vanishing energy-momentum tensor, arXiv:gr-qc/0311001v1, cf. p. 5 and Eq. 23 at this http URL.

17. Jose G. Pereira, Gravitational waves: a foundational review, arXiv:1305.0777v3 [gr-qc], cf. p. 8 at this http URL.

18. H. Bondi, M.G.J. van der Burg, A.W.K. Metzner, Gravitational Waves in General Relativity. VII. Waves from Axi-Symmetric Isolated Systems, *Proc. R. Soc. Lond.* A 21, 269(1336) 21-52 (1962); cf. Bondi's *news field*.

19. James Hartle, *Gravity: An Introduction to Einstein's General Relativity*, Addison-Wesley, 2003, cf. p. 162 at this http URL; Piotr T. Chrusciel, Lectures on Energy in General Relativity, February 22, 2013 (retrieved on 27 August 2015 from this http URL), cf. p. 226 at this http URL and p. 247 at this http URL.

20. Max Tegmark, On the dimensionality of spacetime, arXiv:gr-qc/9702052v2, footnote 4 and Fig. 1.

21. Only biological systems[6], such as the human brain, may obtain qualia from potential reality, experienced as an *extended* moment 'now'[61] from our psychological time: we observe the world and, *at the same time* (Fig. 16), are aware of doing so.

22. Kevin Brown, *Reflections on Relativity*, MathPages, Lulu, August 2015, cf. Sec. 5.8, *The Field Equations*, pp. 384-395, available at this http URL; sec. 8.11, *Paths Not Taken*, pp. 610-617, available at this http URL; and Sec. 9.9, *Locality and Temporal Asymmetry*, pp. 671-677, available at this http URL.

23. J.D. Brown, K.V. Kuchar, Dust as a Standard of Space and Time in Canonical Quantum Gravity, arXiv:gr-qc/9409001v1.

24. Alexander Afriat, Ermenegildo Caccese, The relativity of inertia and reality of nothing, arXiv:0804.3146v7, p. 27.

25. Richard W. Sharpe, *Differential Geometry: Cartan's Generalization of Klein's Erlangen Program*, Springer, 1997, p. 3.

26. David Hilbert, Über das Unendliche, *Mathematische Annalen* **95** (1926), S. 161-190. Translated by Erna Putnam and Gerald J. Massey at this http URL.

27. Charles W. Misner, Absolute Zero of Time, *Phys. Rev.* **186**, 1328-1332 (1969), p. 1331.

28. To the best of my knowledge, the term 'finite infinity' was first suggested by George F R Ellis[54], see: Ellis G F R, Relativistic Cosmology: Its Nature, Aims and Problems, in: *General Relativity and Gravitation*, Ed. B. Bertotti *et al.*, Reidel, 1984, pp. 215-288; Sec. 5.2 and Fig. 11(c).

29. The solutions to the measurement problem in Quantum Mechanics (Schrödinger's cat) and to *the* most widely known public secret in theoretical physics (shown at this

http URL), hindering quantum gravity (Wald[60], p. 382), will be examined in Paper II[1]. If we use *classical* description of the quantum world, as suggested in current literature (e.g., Giancarlo Ghirardi[3]), we can never understand it, just as an Eskimo could never understand elephant's **trunk** by measuring it with two complementary devices, "nose" and "arm" (see pp. 7-8 in HBP.pdf). The quantum state [7] can only be described as an **intact** quantum "trunk", which is neither "particle" nor "wave", does not "collapse" nor "decohere", and is not "uncertain" but *flexible*: God casts the die, not the dice (Einstein).

30. Georg Cantor, Beiträge zur Begründung der transfiniten Mengenlehre, *Mathematische Annalen* **46** (1895) S. 481-512.

31. John A. Wheeler, Time Today, in: *Physical Origins of Time Asymmetry*, ed. by J.J. Halliwell, J. Pérez-Mercader, and W.H. Zurek, Cambridge University Press, 1994, p. 1.

32. Steven Weinberg, *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*, Wiley, 1972, pp. 62-68, p. 93 and p. 106.

33. Karel Hrbacek, Thomas J. Jech, *Introduction to Set Theory*, 3rd ed., Marcel Dekker, Basel, 1999, p. 269, available at this http URL.

34. John Baez, What's the Energy Density of the Vacuum? June 10, 2011 (retrieved on 17 September 2015 from this http URL).

35. S. J. Crothers, J. Dunning-Davies, Planck Particles and Quantum Gravity, *Progress in Physics*, **3** (2006) 70-73; viXra:1103.0054.

36. Sergio Doplicher, The Principle of Locality, arXiv:0911.5136v1 [math-ph], p. 21.

37. Yif Magic, Lightspeed Teleportations, posted on YouTube on December 3, 2012; watch a video clip (33Mb, mp4 format) from this http URL. A demonstration of "levitation" by Steven Freyne is available at this http URL. No, it's not "magic"[63].

38. Michele Maggiore, *Gravitational Waves: Theory and Experiments*, Oxford University Press, 2007.

39. LIGO Scientific Collaboration and Virgo Collaboration, Searches for gravitational waves from known pulsars with S5 LIGO data, arXiv:0909.3583v4 [astro-ph.HE].

40. Robert M. Wald, *Space, Time, and Gravity*, University of Chicago Press, 1992, p. 120; excerpt available at this http URL.

41. Angelo Loinger, GW's towards fundamental principles of GR, arXiv:0709.0490v1 [physics.gen-ph].

42. George Lakoff and Rafael E. Núñez, *Where Mathematics Come From*, Basic Books, New York, 2001, p. 189.

43. Eric Schechter, *Potential versus Completed Infinity*. Online essay, 5 December 2009, retrieved on 22 September 2015 from this http URL.

44. Hyun Seok Yang, Towards A Background Independent Quantum Gravity, arXiv:1111.0015v3 [hep-th], pp. 1-2. To quote from Hyun Seok Yang (p. 2), “the flat spacetime in general relativity behaves like an elastic body with tension although the flat spacetime itself is the geometry of special relativity. (...) That is, the (flat) spacetime behaves like a metrical elasticity which opposes the curving of space. But this picture rather exhibits a puzzling nature of flat spacetime because the flat spacetime should be a completely empty space without any kind of energy as we remarked above. How is it possible for an empty space of nothing to behave like an elastic body with tension ?”

45. Lewis Carroll, *Alice’s Adventures in Wonderland*, Macmillan, 1865, Ch. 6 available at this http URL.

46. Philip Gibbs, Where is the centre of the universe? Online article, 1997, retrieved on 24 September 2015 from this http URL.

47. Timothy Clifton, What’s the Matter in Cosmology? arXiv:1509.06682v1 [gr-qc].

48. Piotr T. Chrusciel, Tim-Torben Paetz, Characteristic initial data and smoothness of Scri. I. Framework and results, arXiv:1403.3558v3 [gr-qc], pp. 2-5.

49. Roger Penrose, Conformal Treatment of Infinity. In: *Relativity, Groups and Topology*, Vol. 1, Ed. by B. DeWitt and C. DeWitt, Gordon and Breach, 1964, pp. 565-584; see the “definition” of the boundary *exactly* at $\Omega = 0$ on p. 565 at this http URL.

50. Jerry B. Griffiths, Jiri Podolsky, *Exact Space-Times in Einstein's General Relativity*, Cambridge University Press, 2009, Ch. 6.4, p. 83; see Fig. 6.8 at this http URL.

51. Robert Geroch, Asymptotic Structure of Space-Time, in *Asymptotic Structure of Space-Time*, ed. by F. Paul Esposito and Louis Witten, Plenum, 1977; see an excerpt at this http URL.

52. E. T. Newman, K. P. Tod, Asymptotically flat spacetimes, in *General Relativity and Gravitation: One Hundred Years After the Birth of Albert Einstein*, Volume 2, ed. by Alan Held, Plenum, 1980, p. 2; see an excerpt at this http URL.

53. Sean M. Carroll, Why is the Universe Accelerating? arXiv:astro-ph/0310342v2.

54. George F. R. Ellis, Physics in the Real Universe: Time and Spacetime, arXiv:gr-qc/0605049v5, see Fig. 4 at this http URL.

55. Tamara M. Davis, Charles H. Lineweaver, Expanding Confusion, arXiv:astro-ph/0310808v2; see an excerpt at this http URL.

56. Peter G. Bergmann, Observables in General Relativity, in *Gravitational Measurements, Fundamental Metrology and Constants*, ed. by Venzo De Sabbata and Vitaly N. Melnikov, Kluwer, 1988, pp. 15-18; see an excerpt at this http URL.

57. Stephen Leacock, Alan Bowker, *On the Front Line of Life. Stephen Leacock: Memories and Reflections*, 1935-1944, Dundurn, 2004; see an excerpt from p. 186 at this http URL.

58. Karel V. Kuchar, The Problem of Time In Quantum Geometrodynamics, in *The Arguments of Time*, ed. by Jeremy Butterfield, Oxford University Press, 1999, see an excerpt from p. 193 at this http URL; Demetris T. Christopoulos, A simple definition of time, *ResearchGate*, 16 June 2014, retrieved from this http URL.

59. C.J. Isham, J. Butterfield, On the Emergence of Time in Quantum Gravity, arXiv:gr-qc/9901024v1, p. 25.

60. Robert M. Wald, *General Relativity*, University of Chicago Press, 1984, pp. 7-8, p. 12 ("we shall consider (…) only manifolds which are Hausdorff and paracompact"), p. 18 ("one and only one curve passes through each point $p \in M$"), p. 72 available at this http URL, p. 382 at this http URL, and pp. 423-426.

61. Ulric Neisser, *Cognition and Reality. Principles and Implications of Cognitive Psychology*, Freeman, 1976, Fig. 2 and Ch. 2 and 4.

62. John A. Wheeler[4], p. 1215: "No acceptable explanation for the miraculous identity of particles of the same type has ever been put forward. That identity must be regarded, not as a triviality, but as a central mystery of physics."

63. Consider, for example, *the* proton *per se* (Fig. 16) keeping all *physicalized* protons (Fig. 17) 'the same'[62]. Suppose there are roughly 10^{82} protons in the observable universe. What makes their genidentity is that all protons are physicalized "shadows" (Fig. 1) cast from their **intact** *potential* quantum state[29] — *the* proton *per se* — which has **zero** probability for *physical* observation: "one of the greatest mysteries of Nature"[64]. As to whether the proton *per se* has a distinctive qualia[21], and whether one can temporarily cancel what we call inertia by "free fall" (REIM) to fly like an Alien Visiting Craft (AVC), such questions are related to spacetime engineering (Paper **III**[1]) and will not be discussed here. Suffice it to say that if the RS spacetime of AVCs can be "inflated" with respect to our RS spacetime by 10^3 ($\mathbf{S_{AB}}$ = 1000, see Fig. 14 and Eq. 2), and if our guests in the AVC fly with, say, 1 m/s (3.6 km/h) in *their* RS spacetime, an observer in *our* RS spacetime (e.g., Kenju Terauchi) will expect from the AVC to "slow down time", just a bit, by flying with 1 km/s (3600 km/h) with respect to *our* RS spacetime. Yet all people, included our guests in the AVC, will enjoy "the same" time rate 1 s/s. Besides, taking "sharp turns" with 1 m/s (3.6 km/s) won't break the AVC. It's all relative.

64. A.D. Dolgov, Cosmic antigravity, arXiv:1206.3725v1 [astro-ph.CO]; an excerpt from pp. 13-14 is available at this http URL.

65. José M.M. Senovilla, Singularity Theorems in General Relativity: Achievements and Open Questions, arXiv:physics/0605007v1, p. 6: "Singularities in the above sense clearly reach, or come from, the *edge* of space-time. This is some kind of boundary, or margin, which is not part of the space-time but that, somehow, it is accessible from within it. Thus the necessity of a rigorous definition of the boundary of a space-time."

66. Adam D. Helfer, Are Negative Energy Densities Detectable? arXiv:gr-qc/9709047v1, p. 1: "T. S. Eliot described a 'mystery cat,' Macavity, responsible for all sorts of mischief, But when the crime's discovered, Macavity's not there! I investigate the negative energy densities predicted by relativistic quantum field theories, and find

they have a similar character. The energy in a region, plus the energy of a device which detects it, must be non-negative. Indeed, as far as has been checked, the total four-momentum density, of the field plus the observing device, must be future-pointing. In consequence the semi-classical Einstein equation can at best describe negative energy-density effects only as long as **no observers are present to test it**: Macavity, Macavity... he breaks the law of gravity."

67. Simon Hewitt, When Do Some Things Form a Set? *Philosophia Mathematica* **23** (2015) 311-337.

68. R. M. Wald, Introduction to Gravitational Self-Force, arXiv:0907.0412v1 [gr-qc]. Naresh Dadhich, On the derivation of the gravitational dynamics, arXiv:0802.3034v1 [gr-qc]; an excerpt from p. 2 is available at this http URL.

69. Every carpenter can understand the essence of Archimedean topology (E. Rosinger, arXiv:0903.0296v2, pp. 5-6): if you have two timbers of different size, say, A = 3m and B = 10m, you can always find a positive integer $0 < k < \infty$, such that if you multiply the smaller A by k, you can produce a timber larger than B, say, if k = 4, 4 x 3 = 12 > 10. But you can never reach some "infinitely large" timber and **stop** there, as with the largest beer in Fig. 10. Ditto to the opposite case of reaching "zero timber" (Eq. 1). **NB**: Only the *physical* footprint in the past (Fig. 3) has Archimedean topology.

70. Philip Pearle, Classical Electron Models, in *Electromagnetism: Paths to Research*, ed. by Doris Teplitz, Plenum Press, 1982, pp. 211-296; see p. 225 at this http URL. Banesh Hoffmann (1964), Negative Mass as a Gravitational Source of Energy in the Quasistellar Radio Sources, in: Thomas Valone *et al.*, *Electrogravitics Systems*, Integrity Research Institute, 2001, pp. 92-96; excerpt at this http URL. Giancarlo Cavalleri, Eric Tonni, Negative masses, even if isolated, imply self-acceleration, hence a catastrophic world, *Nuovo Cimento* 112B (1997) 897-903, available at this http URL.

71. Rod Pierce (22 November 2014), Imaginary Numbers, *Math Is Fun*. Retrieved on 25 October 2015 at this http URL. Eric W. Weisstein, Imaginary Unit, MathWorld - A Wolfram Web Resource. Retrieved on 25 October 2015 at this http URL.

72. Mark A. Armstrong, *Basic Topology*, Springer, 1997, Fig. 5.7, p. 104.

73. Mendel Sachs, *Concepts of Modern Physics: The Haifa Lectures*, Imperial College Press, 2007, pp. 86-87 available at this http URL.

74. Angelo Loinger, Einstein, Levi-Civita, and Bianchi relations, arXiv:physics/0702244v1 [physics.gen-ph].

75. Italo Calvino, The Form of Space, in *Imaginary Numbers*, ed. by William Frucht, Wiley, 2000; excerpt from p. 1 available at this http URL.

76. Kevin Brown, *Reflections on Relativity*, MathPages, Lulu, October 2015, Sec. 3.7 Zeno and the Paradox of Motion, pp. 252-258, available at this http URL.

77. Bryan Bunch, *Mathematical Fallacies and Paradoxes*, Dover, 1997, p. 192; see also an excerpt from pp. 195-196 at this http URL.

78. Thomas Jech, *Set Theory*, The Stanford Encyclopedia of Philosophy (Fall 2014 Edition), ed. by Edward N. Zalta, 2002, available at this http URL.

79. Wolfgang Mückenheim, Sequences and Limits, *Advances in Pure Mathematics*, 5 (2015) 59-61, at this http URL. Ed Nelson, Hilbert's Mistake. Online paper dated March 18, 2007, at this http URL. The two forms of infinity are explained at **this http URL**.

80. Barbara Piechocinska, Wholeness as a Conceptual Foundation of Physical Theories, arXiv:physics/0409092v1 [physics.gen-ph].

81. J.V. Narlikar, Mach's Principle, *Resonance - Journal of Science Education*, April 2011, pp. 310-321, available at this http URL (cf. Fig. 7, p. 317).

82. Kurt Gödel (1949), A remark about the relationship between relativity theory and idealistic philosophy. In *Collected Works*, Volume II, Publications 1938-1974. Ed. by Solomon Feferman *et al.*, Oxford University Press, 1990, pp. 202-203. To quote Kurt Gödel: "Change becomes possible only through the lapse of time. The existence of an objective lapse of time, however, means (or, at least, is equivalent to the fact) that reality consists of an infinity of layers of 'now' which come into existence successively. But, if simultaneity is something relative in the sense just explained, reality cannot be split up into such 'nows' in an objectively determined way. Each observer has his own set of 'nows', and none of these various systems of layers can claim the prerogative of representing the objective lapse of time(footnote 5)."

83. John Walker, The Relativity of Simultaneity. Online paper and animation, January 2007, available at this http URL. To quote John Walker: "In this case, three observers of the same two events see three different orders in which they appeared to occur from their particular vantage points; hence their perception of simultaneity is *relative* even though it is entirely due to light travel time instead of motion."

84. Paul Davies, That Mysterious Flow, *Scientific American*, September 2002, pp. 42-43; excerpt from Sec. 'How Time Doesn't Fly': "The concept of flux, after all, refers to motion. It makes sense to talk about the movement of a physical object, such as an arrow through space, by gauging how its location varies with time. But what meaning can be attached to the movement of time *itself*? Relative to what does it move? Whereas other types of motion relate one physical process to another, the putative flow of time relates time to itself. Posing the simple question "How fast does time pass?" exposes the absurdity of the very idea. The trivial answer "One second per second" tells us nothing at all."

85. Richard Ieuan Garth Hughes, *The Structure and Interpretation of Quantum Mechanics*, Harvard University Press, 1989, Ch. 2.7 The Evolution of States in Quantum Mechanics and Ch. 6.5 Kochen and Specker's Example; see an excerpt from p. 164 at this http URL; Helena Granström, Some remarks on the theorems of Gleason and Kochen-Specker, arXiv:quant-ph/0612103v2, p. **2;** C.J. Isham, J. Butterfield, Some Possible Roles for Topos Theory in Quantum Theory and Quantum Gravity, arXiv:gr-qc/9910005v1, see an excerpt at this http URL.

86. Robert M. Wald, The Arrow of Time and the Initial Conditions of the Universe, arXiv:gr-qc/0507094v1, p. 5.

87. Peter Weiss, Constant Changes, *Science News*, Vol. 160, October 6, 2001.

88. C.J. Isham, *Lectures on Quantum Theory: Mathematical and Structural Foundations*, World Scientific, 1995, pp. 200-204.

* All emphasis and comments in the references and notes are mine - D.C.