

Hyperimaginary Numbers

D. Chakalov
 35A Sutherland St
 London SW1V 4JU
chakalov.net

Abstract

The idea of *hyperimaginary numbers* is suggested as the first step toward the mathematical basis of *res potentia* (Plato), presented in the right-hand side of the evolution equation $|\mathbf{w}|^2 = |\mathbf{m}|^2 + |\mathbf{m}_i|^2$. The real and imaginary (*tachyonic*) components in the right-hand side are always balanced, leading to $|\mathbf{w}|^2 = \mathbf{0}$ – the *physicalized* world is made of *positive mass-energy* only, $|\mathbf{m}|^2$, which is always balanced (not “*conserved*”) by equal amount of $|\mathbf{m}_i|^2$, once-at-a-time, ever since The Beginning (*John 1:1*). God is interpreted as mathematical (hyperimaginary) object residing “inside” the 4D instant here-and-now (*Luke 17:21*), and conceptual solutions to fundamental problems in *point-set topology*, *set theory*, and *number theory* are briefly described.

The full manuscript will be available only on Christmas 2016, upon request.

D. Chakalov <dchakalov@gmail.com>

1. Introduction

Let me offer a simple experiment to verify the connection of your *brain* to the Platonic world¹ dubbed *res potentia*. If compared to the physical time read by your wristwatch, *res potentia* would be *atemporal*, in the sense that “its proper time would stand still”².

Now the experiment. Consider the *meanings* explicated with these four sayings:

1. You can't hide a piece of broccoli in a glass of milk.
2. Who has no horse may ride on a staff.
3. Don't wear polka dot underwear under white shorts.
4. Faute de mieux, on couche avec sa femme.

If you can understand the meanings of these sayings, which of them presented similar meanings? My answer is 1 & 3 and 2 & 4.

Surely every word can be “[encoded](#)” in your [brain](#), but **not** its *meaning*. The latter is **not** “[encoded](#)” in your brain, and therefore cannot be “computed” from the neural presentations of the symbols used in the sayings above (more in [HBP.pdf](#)). These *meanings* (not [words](#)) are *invariant* in all human brains, despite the neural differences between all brains. They do **not** decay and are **not** governed by the laws of thermodynamics. They do **not** evolve in the physical time³ read by your clock either. They spring from some kind of ‘cognitive vacuum’, which belongs to the hyperimaginary *res potentia*. Yes, *res potentia* can act on your brain, but - **no**, it is not mind or consciousness or anything we label with *res cogitans*: check out the doctrine of *trialism* on p. 64 in [gravity.pdf](#) and notice that *res potentia* belongs to the [quantum vacuum](#) as well.

Hence we postulate a *dual* cognitive-and-quantum vacuum as the area of spacetime engineering (tweaking [the least action](#); see Sec. 4 below), and suggest that the mathematical description of this *dual* vacuum should involve so-called *hyperimaginary numbers* collapsed to “points” from the [number line](#).

Before we explain the *evolution* equation⁶ based on hyperimaginary numbers (see Sec. 3), let me set the record straight: we do **not** talk here about psychology and religion, but about a new form of Platonic reality¹ called *res potentia* (check out again p. 64 in [gravity.pdf](#)), thanks to which the *physicalized* universe can be modeled as the “brain” of the Universe. Not the “mind” of the Universe, as suggested in 1927 by Sir Arthur Eddington with his famous statements “[the stuff of the world is mind-stuff](#).” The distinction between the “brain” and the “mind” (if any) of the Universe is crucial. Let me explain it by referring to the speech by Max Planck at Florence, Italy, in 1944:

There is no matter as such! All matter originates and exists only by virtue of a force which brings the particles of an atom to vibration and holds this most minute solar system of the atom together. We must assume behind this force the existence of a conscious and intelligent Geist (bewußten intelligenten Geist). This Geist is the matrix of all matter.

We can talk about ‘the matrix of all matter’ if and only if that such matrix is understood as an *enclosure* within which the quantum-gravitational world originates as **re**-created *physicalized* world – once-at-a-time, as read with a clock. This matrix is the “[brain](#)” of the Universe. It is not “mind” or anything labeled with *res cogitans*, but Platonic *res potentia* explicated from what shows up in the inanimate physical world as “[vacuum](#)” and “[aether](#)”.

Let me explain *res potentia* with a simple example of the *matrix* for a photon (later I will explain the matrix for a proton⁴), stressing that the matrix itself defies any probabilistic (Sic!) description. It does **not** decay nor evolve in the physical time^{3,19} read by your clock.

Imagine that you enter your living room at night, and you switch on the light. If it is a **light bulb**, it will emit photons with rate app. 1.8×10^{20} photons per second. That's a huge number: 180,000,000,000,000,000 photons per second. All photons are identical⁵ and have particular wavelength corresponding to the “distance” (if any) between the two “orbits” (if any) of electrons (see **h** in Fig. 1 below).

How come nothing goes wrong with producing 1.8×10^{20} identical⁵ photons per second, ever? Because of the “matrix” for a photon¹⁷. It exists with *certainty*. It is *res potentia*.

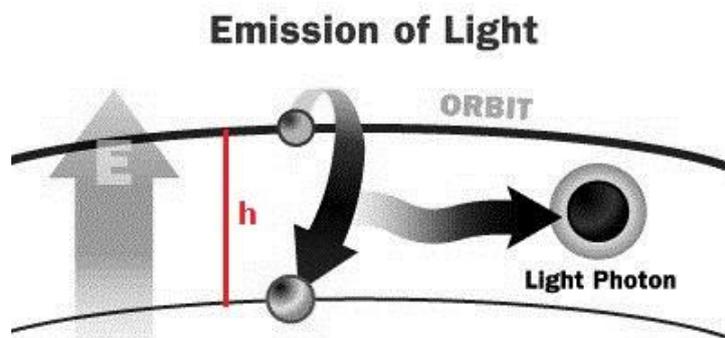


Fig. 1

As John A. Wheeler⁵ acknowledged, the identity of particles of the same type is “a central mystery of physics.” The identity of ‘**international second**’ (Sec. 4) is not less mysterious.

Recall also another mystery of physics, which is also resolved with the Platonic matrix for quantum particles: the most widely known, ever since 1911, public secret in physics, shown at [this http URL](#).

Now let me elaborate on the matrix for a proton⁴. I will reexamine it later, to explain the *evolution* equation⁶ based on hyperimaginary numbers, $|\mathbf{w}|^2 = |\mathbf{m}|^2 + |\mathbf{m}_i|^2$ – the squared mass $|\mathbf{m}|^2$ refers to the identity⁵ of protons⁴ and to the ubiquitous mass-energy **non-conservation** acknowledged by Paul Steinhardt⁷ and by many others¹⁶.

The squared imaginary mass² $|\mathbf{m}_i|^2$ provides uncancelled forces^{8,9} and free **acceleration**, in violation of Newton’s third law and without limit: $|\mathbf{m}_i|^2$ will be attracted by the positive mass $|\mathbf{m}|^2$, while the latter will be repelled by it¹⁰ (self-accelerating motion, [Wikipedia](#)). The negotiation between $|\mathbf{m}_i|^2$ and $|\mathbf{m}|^2$ is not physical but *atemporal* phenomenon residing **along W**, “**before**” light. We can observe only the *physicalized* end result from the negotiation: it is **not** squared and is made of positive mass only⁴, as in Einstein’s $E = mc^2$.

Let’s go back to the matrix for a proton. As Alex Dolgov⁴ demonstrated, the error margin for producing proton’s mass is “**one part to 10⁴⁵**”. Such astonishing precision cannot be accomplished without proton’s matrix as *res potentia*. In fact, the physical world is *perfectly* tuned for biological structures, which physicists call ‘**anthropic principle**’.

In general, the living and quantum-gravitational worlds offer the necessary condition for their existence, while the matrix of *res potentia* is the sufficient condition. It’s a bundle¹⁸. Physically, the matrix – the “memory” of the physical world – will induce wave-like holomovement¹¹ without any **physical** source of such waves, and all biological systems (e.g., the **human brain**) and quantum-gravitational systems will exhibit **self-action**¹⁰, because the delocalized *res potentia* cannot be **physically** detected. If the matrix were *physical* object endowed with **metric**, it would have to be some sort of “**background**” of

spacetime (you cannot paint a painting [without any canvas](#)), which could miraculously act on the spacetime but *without* being acted upon, contrary to [Newton's third law](#). Such issue never arises here, because the [matrix](#) is Platonic *res potentia*. It certainly acts on the quantum-gravitational “brain” of the Universe, but since the [matrix](#) is not physical entity, the back action by the “brain” only enriches its “memory”.

To sum up, the *res potentia* of the physicalized universe (‘the matrix of all matter’, [Max Planck](#)) acts as ‘finite infinity’ (FI: check out p. 67 in [gravity.pdf](#)) and leads to dual age cosmology¹. The [evolution equation](#) of the entire Universe is reduced at The Beginning ([John 1:1](#)) and at The End to meaningless identity ‘ $0 = 0$ ’: once created, the Universe is *already* eternal (physical theology¹). Namely, at every 4D instant ‘here and now’, the Universe passes through God at [absolute infinity](#) ([Luke 17:21](#)). Mathematically, *res potentia* fixes [Dirichlet boundary conditions](#) and [Cauchy conditions](#) for the **re**-created and non-unitary (**Sic!**) evolution of the Universe, starting from *the most simple physicalized* state, much like our [first prenatal stage](#) ([Zygote](#)): Time is God’s way to keep everything from happening all at once. Hence we have genuine free will, but the *potential* future is ‘open’ to brand new events, including the ‘unknown unknown’. You never know with the future.

Let’s see how we can unravel *res potentia* in the ‘atom of geometry’.

2. About points, if any

The definition of ‘point’ (if any) resembles those of ‘[vacuum](#)’ or ‘[empty set](#)’: it only tells you what the so-called ‘point’ is not; for example, “that which has no part” ([Euclid](#)). It is some kind of dimensionless entity devoid of any metric, which is why the ‘point’ is by no means ‘the smallest region of spacetime’, as people may be inclined to think. It defies the application of bipolar notions such as ‘large vs. small’ and ‘one vs. many’. It would be like a bare label (the grin of the cat *without* the cat, Fig. 2 in [The Spacetime](#)¹), provided that we cannot ask the question ‘label of *what?*’, which makes its definition terribly intricate.

Also, the so-called ‘point’ is not related exclusively to physics (check out again the doctrine of *trialism* on p. 64 in [gravity.pdf](#)), as you demonstrated, with your good old [brain](#), by referring to the *meanings* of the four sayings in Sec. 1 [above](#): we all operate with some sort of ‘cognitive vacuum’, which is **UN**speakable and cannot be even comprehended. Yet the set of ‘everything that **can** be comprehended’ can be defined only relationally, only with respect to the complementary set of ‘everything that **cannot** be comprehended’.

How many elements build up such non-trivial “empty set”? Wrong question. It is the Kantian [Noumenon](#) or ‘[Das Ding an sich](#)’, an absolute “vacuum” that can be *never* looked at, as in Plato’s [allegory of the cave](#). Thanks to the “speed” of light¹⁷, we cannot “turn around” and “look” at the cognitive-and-physical vacuum – the ‘light source’ in Fig. 5 in [The Spacetime](#)¹ – explicating *res potentia* as the [matrix](#) of our world.

To explain how we end up with such heavy metaphysics, I will use a Gedankenexperiment. Suppose you are on a ship cruising in the Pacific Ocean, and you can only see an endless [blue](#) ocean around you. Now you decide to look at the ocean through a funnel, which is like a pipe that is wide at the top and narrow at the bottom, say, [1 cm](#). You will again see a [blue](#) spot from the endless ocean, and may also notice that the [blue](#) spot with size [1 cm](#) is changing in time. But suppose the opening of the funnel has been shrunk from [1 cm](#) to the “size” of the [infinitesimal](#) displacement in space, [ds](#) (Fig. 2), matching “that which has no part” ([Euclid](#)).

What “part” from the endless **blue** ocean will you see? An **infinitesimal**, mathematicians would probably say. Physicists will perhaps argue that you have hit the so-called Planck scale¹² and should not be able to see any “color” (**metric**).

Whatever the case is, don’t mix the funnel with the endless ocean around you: they are *ontologically* different entities, as Plato argued twenty-five centuries ago (see **above**).

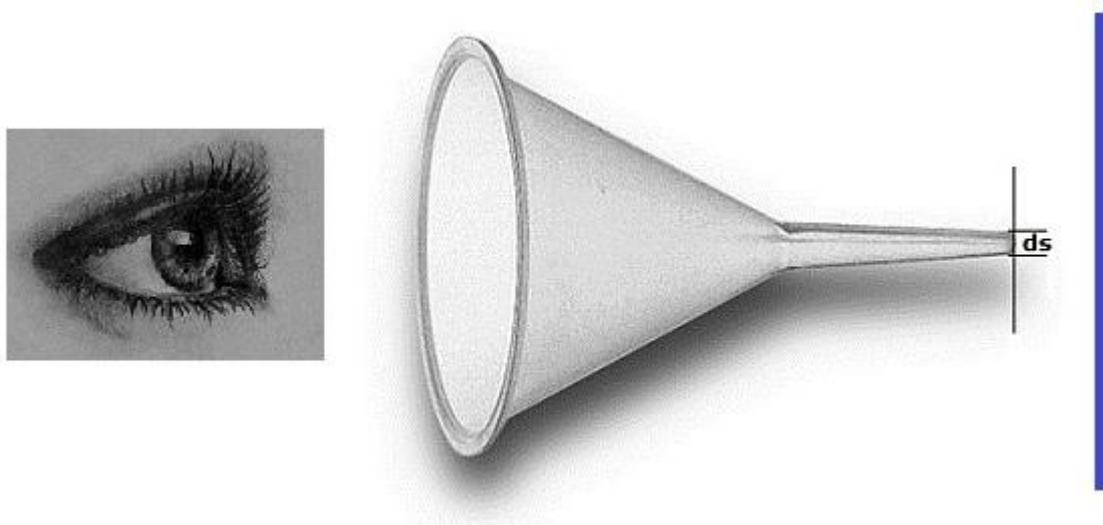


Fig. 2

The funnel stands for the *physicalized* universe – you can also look at the opposite, perpetually inflating physical world, and wonder what could possibly insert *any* limit on its size¹³. The limit is the same endless **blue** ocean, which is *res potentia* wrapping the entire *physicalized* universe (check out ‘finite infinity’ and dual age cosmology **above**).

The next step toward the **hyperimaginary numbers** is to place the *physicalized* universe in the irreversible **past** and *res potentia* in the potential **future**: see Fig. 7 in *The Spacetime*¹. Hence they will be *both* separated by the interface ‘here and now’, in order to preserve their ontologically different nature, *and* connected by the *flow of events* (*ibid.*, Fig. 22), known as the **Heraclitus river**: you could not step twice into the same river.

In the next section, I will introduce a new *hyperimaginary* axis, denoted with **W** (from the German *wunderbar*, as a tribute to **Theodor Kaluza**). In the *physicalized* world of the “funnel” (Fig. 2), the hyperimaginary numbers are *always* collapsed to “points” from the **number line**. Perhaps this is the reason why mathematicians have not yet noticed them. To explain the *temporal* structure and topology of what we casually call ‘spacetime point’, I will use the **limit of a sequence** and Fig. 2, and then explain the *hyperimaginary* axis **W**.

Later in Sec. 4, I will elaborate on the hypothetical mechanism of generating mass-energy, implied in the **evolution equation**, stressing that the phenomenon we call ‘gravity’ is by no means restricted to the fact that apples can fall from trees and hit someone’s head, as **Newton** has observed. Gravity⁷ couples to the entire “pool” of *physicalizable* (Sic!) positive/negative energy⁴ – not just to positive **energy difference** – and hence gravity “knows” the *indefinable vacuum energy* even “**before**” it becomes *physicalized* as positive mass-energy only¹⁷ (Fig. 4), to **re-create** the physical world, with **astonishing precision**. This is the future of physics and life sciences, leading to spacetime engineering (Sec. 4).

3. Hyperimaginary numbers

If the alleged ‘point’ denoted with ds in Fig. 2 was physical stuff endowed with metric viz. Archimedean topology (Fig. 6 and pp. 11-12 in *The Spacetime*¹), we will inevitably hit the Thomson’s lamp paradox. It is agonizingly clear that we *must not* be able to hit the ‘atom of geometry’ from the physical “funnel” (Fig. 2). If we could, at least in principle, hit the spacetime ‘point’ in any *physical* way, we will need many “miracles” to recover from it.

Physically, we 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” the “big bang”, when the spacetime was just about 1 cm across (Fig. 2) and a causally connected region would have been only 10^{-24} cm across (the horizon problem), in such way that one could later “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 scale¹² at which the spacetime “points” have become *totally* fuzzy and locality¹⁷ has lost *any* meaning¹⁴.

Briefly, if we wish to explain the fact that time and space exist, we must introduce the matrix of spacetime, like we did for the matrix of photons (Fig. 1). Notice that every ‘matrix’ is Platonic *res potentia*, which do not have size or any physical attributes, much like the *idea* of a ‘tree’ is not smaller than the *idea* of a ‘mountain’. It is not clear whether we can make a ‘set’ of different instances of ‘matrix’, because the cardinality of such ‘set’ will have to be indefinable: the future is ‘open’ to brand new events, as stated above.

For mathematical point of view, we must make sure that the Platonic *res potentia* has unique presentation based on hyperimaginary numbers, as it always resides in the potential future and only casts a physicalized “jacket” on the number line – one-jacket-at-a-time. Since the real numbers refer to the physicalized world placed in the irreversible past (see above), they must be totally de-coupled from the hyperimaginary numbers.

Geometrically, the hyperimaginary numbers should be depicted with 4D sphere \Leftrightarrow saddle transitions (Fig. 3.1) passing through God at every instant ‘here and now’ (Fig. 3.2).

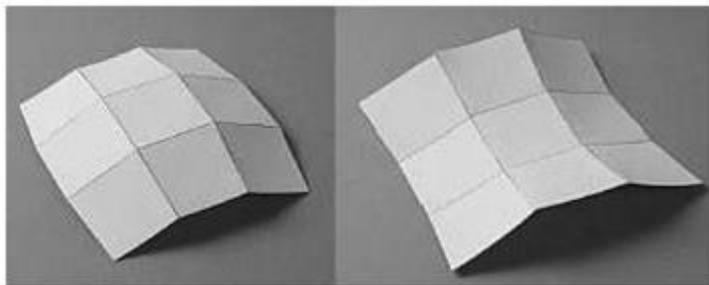


Fig. 3.1

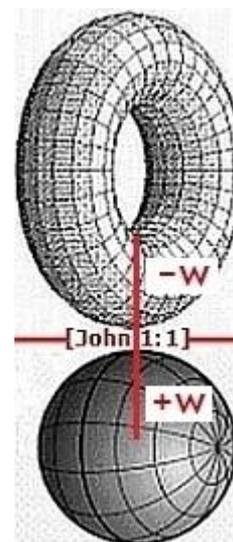


Fig. 3.2

At the end of Sec. 4, I will try to explain the problems with delocalization¹¹ of gravity and spacetime engineering (often camouflaged as “magic”). The first obvious obstacle is to relate Fig. 3.2 above to the two “mirror” words, material and tachyonic², and to the three types of masses shown in Fig. 4, borrowed from Yakov Terletsii¹⁵.

According to (24.1), the proper mass is a real quantity if the vector P_k is time-like (i.e., $M^2 > 0$) and an imaginary quantity if this vector is space-like (i.e., $M^2 < 0$). The case of zero proper mass ($M = 0$) can be considered as a special case of real proper mass.

Thus, if the components of the vector P_k are taken to be arbitrary real numbers, then formula (24.1) admits of three essentially different physical systems:

1. systems with positive proper mass, i.e., $M^2 \geq 0$, $E > 0$;
2. systems with negative proper mass, i.e., $M^2 \geq 0$, $E < 0$;
3. systems with an imaginary proper mass, i.e., $M^2 < 0$.

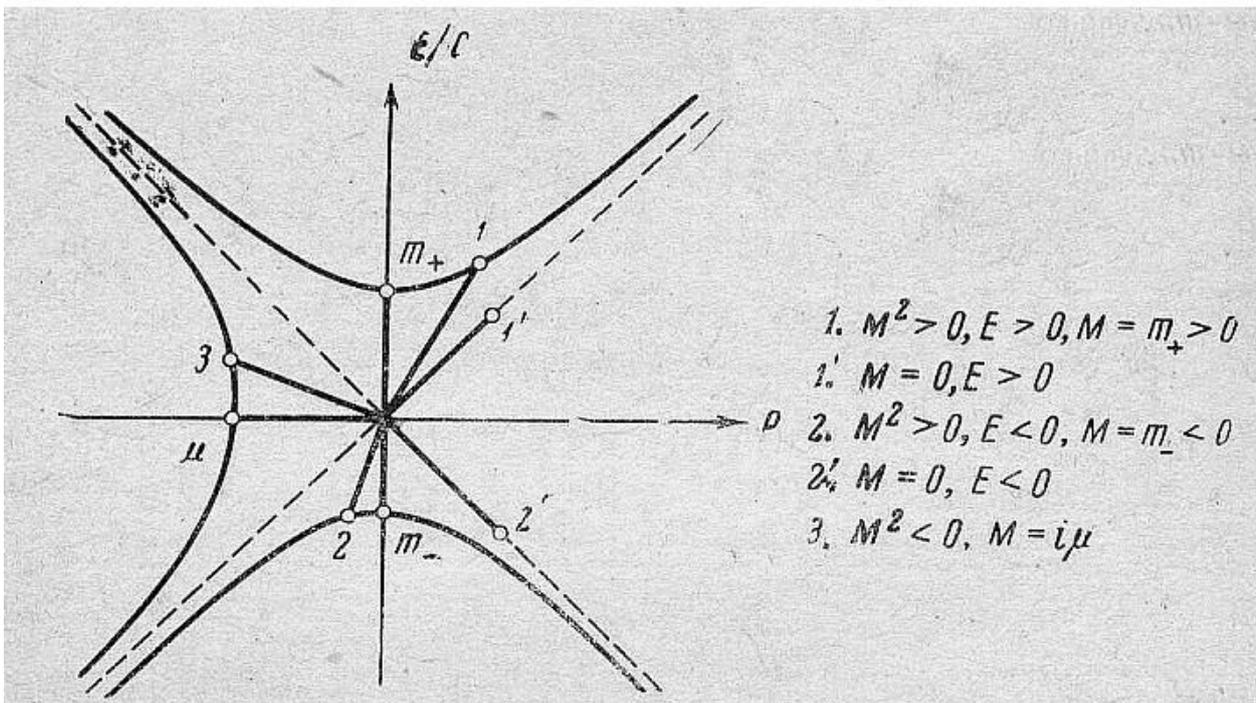


Fig. 4

Briefly on the geometric presentation of hyperimaginary numbers: the horizontal line in Fig. 3.2 above marks the sphere \Leftrightarrow saddle transitions (Fig. 3.1) at the instant at which the hyperimaginary sphere and torus are inflated exactly to infinity. The physical spacetime, endowed with positive mass-energy only, is tending asymptotically toward the horizontal line in Fig. 3.2, from both directions along W , from “south” (hyperimaginary sphere) and from “north” (hyperimaginary torus). Hence the physical, asymptotically flat spacetime is the arena at which the hyperimaginary sphere and torus “clash” into each other, like two

opposite waves, leading to their *complete cancellation* in the physical world ($|\mathbf{w}|^2 = 0$), producing only one physicalized remnant from them – one re-created remnant at a time.

As stated [above](#), I will show the atom of geometry, called ‘point’ and denoted with ds in [Fig. 2](#). It can be explained with the [limit of \(bounded and monotonic\) sequence](#), depicted in [Fig. 5](#) (borrowed from [Wikipedia](#)).

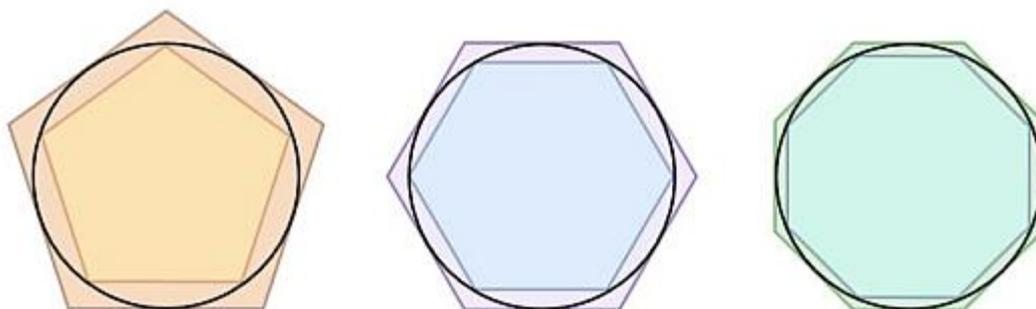


Fig. 5

This sequence has a *limit* at “infinity”, such that the side of the inscribed polygon, denoted with a in [Fig. 6a](#), becomes *identical* to the side of the circumscribed polygon b ([Fig. 6a](#)) and to their distance ds ([Fig. 6a](#) and [Fig. 2](#)). Notice that ds does not have *metric* any more – there is no underlying spacetime to define such metric – and therefore we cannot attribute any number to it. If ds was ‘the smallest pixel of spacetime’ ([Fig. 6b](#)), say, the [Planck length](#) (10^{-35} m), we could reproduce any *finite* region of spacetime (e.g., 1m by $10^{-35} \times 10^{35} = 1$). Therefore, at ds the Archimedean topology is not valid any more.

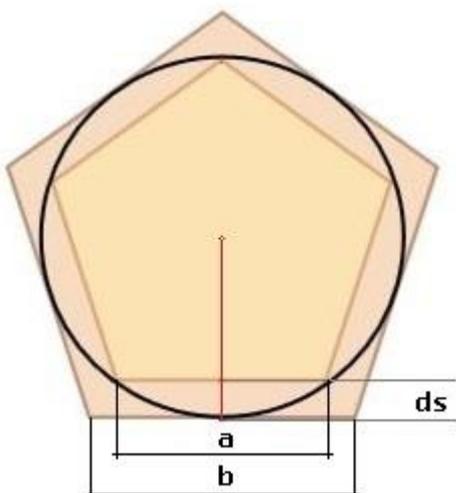


Fig. 6a

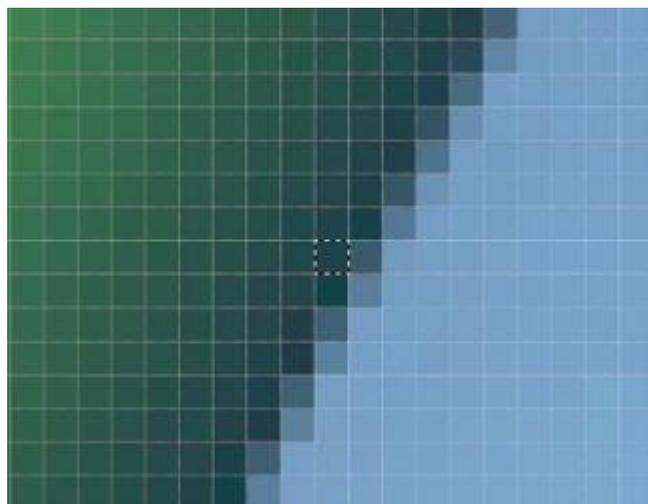


Fig. 6b

Due to the absence of metric, there is no difference between the infinitesimal ds ([Fig. 6a](#) and [Fig. 2](#)) and the infinitesimal dt ¹⁹. They build up the atom of geometry, and lead to a [completely different world](#): the Platonic *res potentia* as “that which has no part” ([Euclid](#)).

The infinitesimal ds & dt ¹⁹ only has a “footprint” on the [number line](#), and the *integration* of such footprints is defined by *actual* infinity (see p. 67 in [gravity.pdf](#)), thanks to which

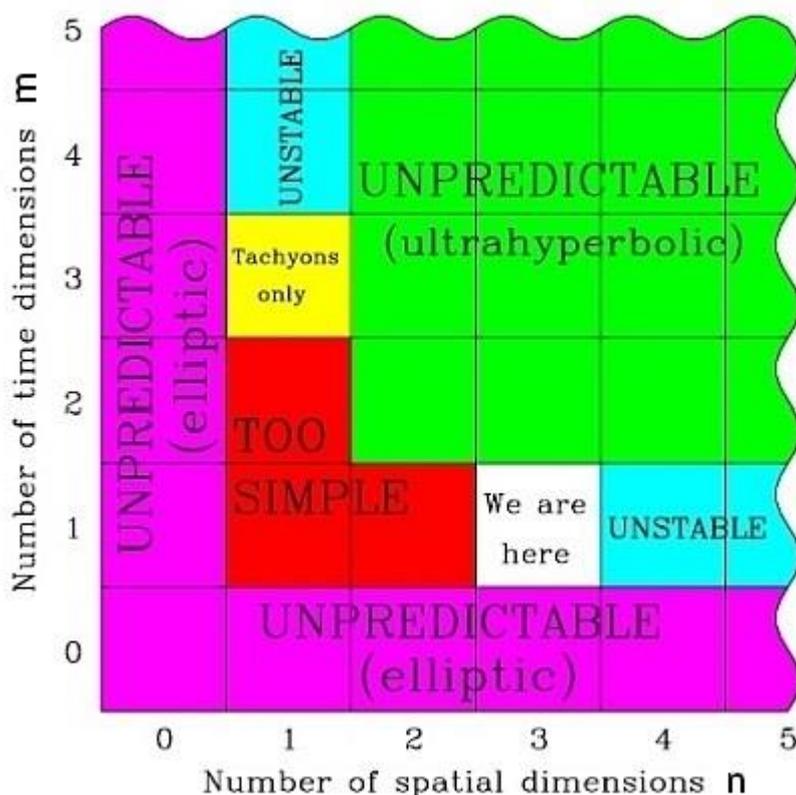
we have physicalized world cast in the **irreversible past**. Again, thanks to *actual* infinity the infinitesimal ds & dt ¹⁹ builds up the physicalized world located in the **irreversible past**, while its hyperimaginary component is placed in the **potential future** as *res potentia*: **it's a bundle**.

(TBC)

November 19, 2016, 10:59 GMT

References and Notes

1. D. Chakalov, The Spacetime. Online paper, Easter 2016, available at [this http URL](#).
2. Max Tegmark, On the dimensionality of spacetime, [arXiv:gr-qc/9702052v2](#), 5 April 1997.



Since a mere minus sign distinguishes space from time, the remaining case $(n,m) = (1, 3)$ is mathematically equivalent to the case where $(n,m) = (3, 1)$ and all particles are tachyons [14] with imaginary rest mass.

Footnote 4: The only remaining possibility is the rather contrived case where data is specified on a null hypersurface. To measure such data, an observer would need to “live on the light cone”, i.e., travel with the speed of light, which means that it would subjectively not perceive any time at all (its proper time would stand still).

3. Wolfgang Tichy, The initial value problem as it relates to numerical relativity, [arXiv:1610.03805v1 \[gr-qc\]](#), 12 October 2016.

Spacetime is foliated by spatial hypersurfaces in the 3+1 split of General Relativity. The initial value problem then consists of specifying initial data for all fields on one such a spatial hypersurface, such that the subsequent evolution forward in time is fully determined. (...) There is a lot of freedom in choosing such initial data. This freedom corresponds to the physical state of the system at the initial time.

4. Alexander Dolgov, Cosmic antigravity, [arXiv:1206.3725v1 \[astro-ph.CO\]](https://arxiv.org/abs/1206.3725v1), 17 June 2012; read an excerpt from pp. 13-14 at [this http URL](#).

5. John A. Wheeler *et al.*, *Gravitation*, W. H. Freeman, 1973, 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.

6. D. Chakalov, Potential Reality I: Relative Scale Spacetime, viXra:1410.0194, 8 November 2015, Eq. 3, pp. 24-25.

7. Paul Steinhardt explains energy conservation, 17-03-2011; watch 1:36-2:00. <https://www.youtube.com/watch?v=tjmNW3mlisE>

8. W. B. Bonnor, [Negative mass in general relativity](#), *Gen. Rel. Gravit.* 21 (1989) 1143-1157; Scott I. Chase and John Baez, Do tachyons exist? Online paper, September 2015, available at [this http URL](#).

9. Robert L. Forward, [Negative matter propulsion](#), *J. Prop. Power* 6 (1990) 28-37.

There is also no violation of the law of conservation of energy. When the two objects are at zero velocity, the total energy of the system is zero. After the two objects have reached v , their combined kinetic energy ΣP is still zero (I multiplied the equation by 2 to simplify its form)

$$2\Sigma E = 2E_+ + 2E_- = (+M)v^2 + (-M)v^2 = 0 \quad (2)$$

because the ball of negative matter has negative kinetic energy.

In addition, it requires no energy to make the marvelous negative matter ball to run our miraculous negative matter propulsion system. As long as we generate positive and negative matter in equal amounts during our fabrication process, the total energy needed to provide the rest mass for the combined system is zero

$$(+M)c^2 + (-M)c^2 = 0 \quad (3)$$

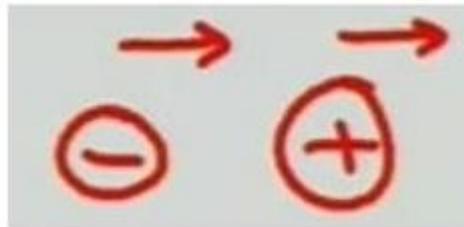
because the negative matter ball has negative rest mass energy.

10. Robert Nemiroff, Physics Lecture:- Negative Mass. November 10, 2010, https://www.youtube.com/watch?v=qnUs4_26D9o

Negative Mass: Runaway Pairs

Say you have a positive and negative mass right next to each other. How do they interact gravitationally?

- The positive mass would attract the negative mass.
 - The negative mass would move toward the positive mass
- The negative mass would repel the positive mass.
 - The positive mass would move away from the negative mass
- Together the two would "run away" in the direction of the positive mass



11. Dimi Chakalov, Holomovement of Fish, December 14, 2015, <https://www.youtube.com/watch?v=0YDqxC9fzT4>

Wave-like holomovement can be observed by looking how a centipede [moves its legs](#), but what makes the holomovement of fish special is that we cannot suggest some signals bootstrapping the participating fish through paths in spacetime. Every fish is *flexible* (not *stochastic*) in choosing one of its **next** states along its (perfectly *local*) trajectory, under the condition that this next **future** state will be *again* *EPR-like correlated* with the entire school of fish. Thus, every individual fish provides the *necessary* condition (see [above](#)) for negotiating its next **future** state along its trajectory, while the school of fish provides the *sufficient* condition for correlating the trajectories of **all** fish, by keeping the matrix as *res potentia* of the holistic school of fish: the entire school of fish 'there' defines the state of every local fish 'here' and *vice versa*, just like with the appearance of '*inertia*'. Also, the [two conditions](#) produce 'waves' in the living and quantum-gravitational worlds, without any *physical* source of waves (say, an oscillating *drum* producing sound waves). As a textbook example, recall the so-called quantum waves: their *origin* is *completely unknown*. Also, while you were reading the four sayings in Sec. 1 [above](#), your brain produced billions of perfectly correlated *chemical synapses*, resulting in wave-like holomovement of electrical impulses along *neural pathways*.

12. Stephen J. Crothers, Jeremy Dunning-Davies, Planck Particles and Quantum Gravity, [viXra:1103.0054](#), 14 March 2011.

13. Powers of Ten™ (1977), August 26, 2010. <https://www.youtube.com/watch?v=0fKBhvDjuy0>

14. Sergio Doplicher, The Principle of Locality, [arXiv:0911.5136v1 \[math-ph\]](#), p. 21.

15. Yakov P. Terletsii, *Paradoxes in the Theory of Relativity*, Springer, 1968, Ch. VI, pp. 83-115.

16. 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](#).

17. Kevin Brown, *Reflections on Relativity*, MathPages, Lulu, August 2016, Sec. 9.9, *Locality and Temporal Asymmetry*, pp. 671-677, available at [this http URL](#).

18. Many (otherwise smart) people are brainwashed by “materialism” and anti-theism, and deeply believe that the ‘bundle’ above is false. Don’t forget that anti-theism is a very sticky religion, from which you may never recover. A typical example is shown below.

Sean Carroll On Death And The Afterlife, 14 March 2015, watch 05:08-06:15.
https://www.youtube.com/watch?v=uQNnvfMjd_Y

Why an afterlife isn't credible:

- The mind is the brain.
- The brain is made of atoms.
- We know how atoms work.




No, we don’t know how atoms work – read [Max Planck](#) and recall the most widely known, ever since 1911, public secret in physics [above](#). As an illustration of our knowledge of how atoms work, imagine a group of monkeys in a zoo, and a large yellow button placed in their cage, such that any time a monkey presses the yellow button, a ripe banana will immediately show up on the top of the button. Surely every monkey would “know” how to “produce” bananas, even if the bananas are not attached to the yellow button in any way whatsoever. Now check out the generation of photons in Fig. 1 [above](#) and recall that every photon has not been “attached” – in any way whatsoever – to its electron **before** (Sic!) it was produced. We only know the “yellow button”: Einstein’s $E = mc^2$. As Erwin Schrödinger stressed in his *Die gegenwärtige Situation in der Quantenmechanik* from 1935,

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

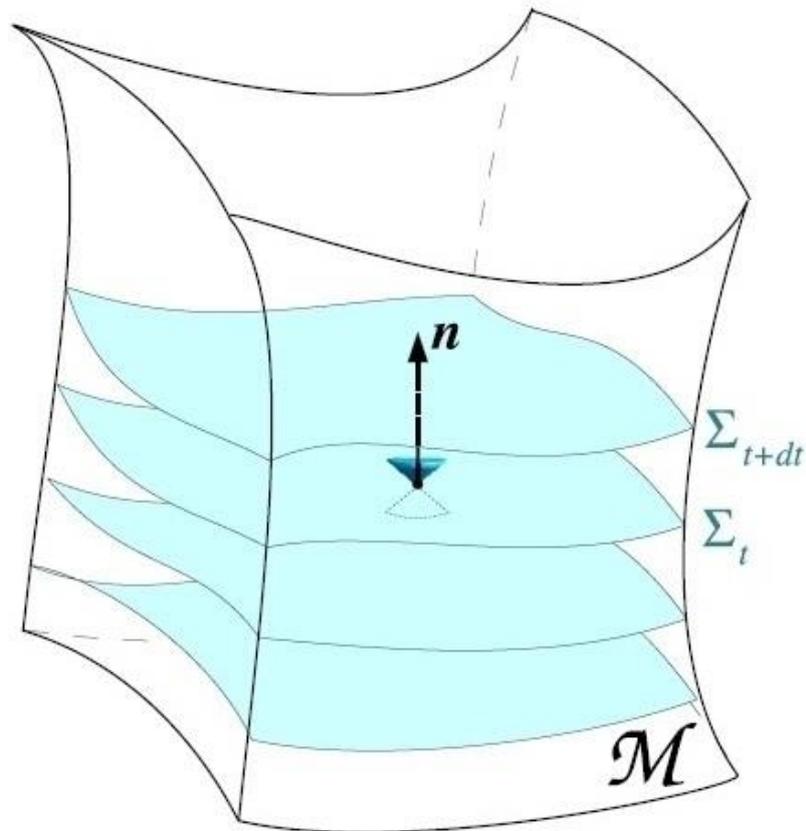
It means that we are dealing with *res potentia*, as acknowledged by [Werner Heisenberg](#). Physically, it was “zero”, both before *and* after it produced a [photon](#) or “ripe bananas”. Details in the evolution equation [above](#).

19. Ericourgoulhon, 3+1 Formalism and Bases of Numerical Relativity, [arXiv:gr-qc/0703035v1](https://arxiv.org/abs/gr-qc/0703035v1), March 6, 2007. The drawing by Ericourgoulhon (emphasis mine) is reproduced below.

Each hypersurface Σ_t is called a *leaf* or a *slice* of the foliation.

We assume[?] that all Σ_t 's are spacelike and that the foliation covers \mathcal{M} :

$$\mathcal{M} = \bigcup_{t \in \mathbb{R}} \Sigma_t.$$



Foliation of the spacetime \mathcal{M} by a family of spacelike hypersurfaces $(\Sigma_t)_{t \in \mathbb{R}}$.

(borrowed from E.ourgoulhon, 3+1 Formalism and Bases of Numerical Relativity, gr-qc/0703035v1)