# Time Matters

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## Abstract

*Time matters* means "issues about time": philosophers – Bergson (1896) and Husserl (1928) among the most appreciated – delved into our relation with past and future, thus with memory and semantics. That is one of my concerns in this paper, framing time in epistemology, developing ideas I approached from different perspectives in the last ten years. That remark implies *time matters* means also "time is important" for life: our cognitive perceptions are central in analyzing our relation with time – neuroscientists like Eagleman (2009) reckon it – and perceptions play a key role (even) in analyzing our scientific understanding of time. The cognitive relevance of experience is another concern of this paper, suggesting how theories rely on experience, as Rovelli (2017: 29-31) noted, bounding perception of one-way direction of time to entropy, and bounding entropy to cognitive perceptions (a vicious circle). Last, but not least, *time matters* means "substance or mass defines time": Bergson (1896) stated a seminal idea on that topic, and physicists – from Minkowski (1909) to Feynman (1949a) to Rovelli (2017) – keep delving into chronotope paradoxes, but paradoxes keep rising in theoretical physics. That is the third concern of this paper, for I (re)frame (fig. 3) the one-way direction of time – just like Fantappié (1944) suggested to do – on the basis of the seminal idea of Bohm (1980), for events could be thought of as portions of a complex unified field – a lattice, in simplified geometric terms, for the sake of representation (fig. 7).

I capture those ideas in an informal way, but saving the essential references, diagrams and mathematics. Physicists could refuse that approach (for they tend to prefer formal rigor and they are well acquainted with spacetime basics), but please try to save the few original propositions from this paper. What we commonly think about time (just like about anything else) relies both on the structure of our culture (Sperber 1996 stated seminal concepts on that topic) and on the structure of our own mind: both culture and mind rely both on material structures (people, books, brains, etc.) and on abstract structures (ideas, associations between ideas, etc.). That meaning a circular relation keeps linking matter (order) and "meta-matter" (disorder), wich I try to frame in the terms or our relation with (what we think about) time.

# 1. Tools

Chronotope represents the evolution through time of events occurring in space: e.g. a stationary body starts moving toward a new position, then it decelerates and stops. In order to depict that displacement, Minkowski (1909) adopted the horizontal axis (*X*) of a Cartesian graph to represent two directions (left and right) of one spatial dimension, and the vertical axis (*Y*) to represent one direction of time dimension (from past to future, upwards): it would be impossible to depict four dimensions (three for space and one for time) on a plane, therefore spacetime diagrams simplify the representation of space to one single dimension.

Minkowski represented what we could think of as the "time of speed of light" (*ct*) on the vertical axis, instead of mere time (*t*). That way, the diagrams represent events in relation to the constant velocity of the propagation of light in empty space ($c$ = 299792458 $^{m}/_{s}$), adopted as the invariant reference frame for every event, according to special relativity of Einstein (1905). Moreover, spacetime diagrams correlate space (*s* on the horizontal axis) to space (*ct* on the vertical axis) because $ct = (^{s}/_{t})t$, that meaning $ct = s$, therefore the diagrams frame time (*t*) in terms of space (*s*), correlating (different) things (*s* and *t*) according to one same category (*s*): a meter in space stands for a "meter" in time, traveling at the speed of light (*c*).

The adoption of *c* as a constant reference for spacetime diagrams implies the representation of events "in the frame of *c*": that meaning, first of all, the diagrams should represent the propagation of light in empty space; then they can represent events in that frame. The diagram in fig. 1 represents the propagation of a ray of light as a bisector ($ct = s$) 45° sloped: one unit on *s* axis is equivalent to one unit on *ct* axis; the ray of light covers every meter in space (*s*) taking one unit of time in terms of its speed (*ct*).

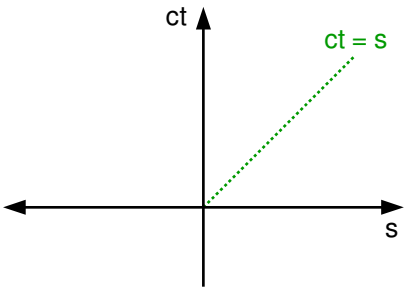

*Figure 1: A ray of light*

Horizontal axis (*s*) means that all the space exists beyond the position of the ray of light: the ray of light from "here and now" – at the intersection of axes ($ct = 0$) – will travel to the right, covering all the space, through which nothing could travel faster than $ct = s$ because *c* is the constant speed limit in the universe, according to special relativity of Einstein (1905). Therefore a body travels within the area included between vertical axis (*ct*) and bisector ($ct = s$): underneath that bisector the graph represents bodies traveling faster than light or bodies impossible to relate with the "here and now", until they enter the *area of possibilities*, above the bisector.

The light and other objects travel in both directions of space (*s*), therefore diagrams reflect the bisector on the left side of the graph, generating an upward *light cone*, thinking the axes as planes: simple diagrams usually represent events within that upward area (or within the volume of the upward cone, imagining a 3-dimensional representation),

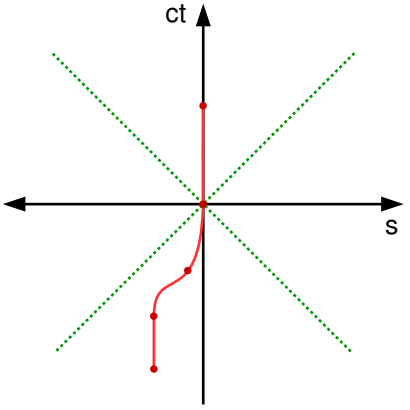

*Figure 2: Light cones*

which depicts the future. Besides, lower part of the diagrams depicts the light cone of the past.

The diagram in fig. 2 represents in red the example referred in the beginning of this chapter: an object was resting in a place (for the first small vertical segment of time); then it accelerated, moving left to right (in the first curved section); then the object kept moving, decelerating (in the second curved section); until my "here and now" (at the intersection of axes), where the object will stay still, resting at my same place (for the last long vertical segment, along *ct* axis).

Physicists represent the events[1] usually from "here and now" (from the intersection of axes) toward the upper section of diagrams, but that practice misleads our vision of time: because the upper section of diagrams represents *future* events, therefore events depicted in the upper section represent just hypotheses, because here and now nobody sees or knows the future – just like the diagrams describe only events bottom-to-top (*ct* arrow points up); otherwise (top-to-bottom) diagrams would describe events traveling back in time, which is an impossible occurrence *in our experience*.

Diagrams should represent events and experiments only in the lower section, because we observe the *past* when we observe an event: everything we experience occurred in the past; we always perceive the past via our five senses. We live in the past because events that we perceive here and now came to our senses a little bit later than the moment the events themselves occurred; then our minds processed information; then our consciousness arises[2]. We live in the illusion of "here and now" just because of the "short distance" separating us from daily events we experience: but, for instance, when we look at a star in the sky, we see an "old" light, which traveled through open space to our eyes for years; that star lies in our future while we perceive it in our "here and now", seeing its past. That meaning the future of that star already exists in our present time, and that future would be its past when it will "come" to our present time. "Now" depends on distance – on space (*s*): that is why diagrams represent here and now as the single point of origin ($0_s$, $0_{ct}$) where distance is zero on both axes.

Our experience of reality occurs here and now only, where – and when – data from the past and from the "so-called" future interact incessantly one another: here and now our minds represent correlations between (representations of) past events, according to Husserl (1928); and mind gathers data of future events, which already occurred, even if we refer to them in terms of "future" just because them events are still to come to our senses. Therefor we could adopt spacetime diagrams structured like the one represented in fig. 3 – where events get to here and now from opposite directions of the same looped timeline[3] – that appears to be consis-

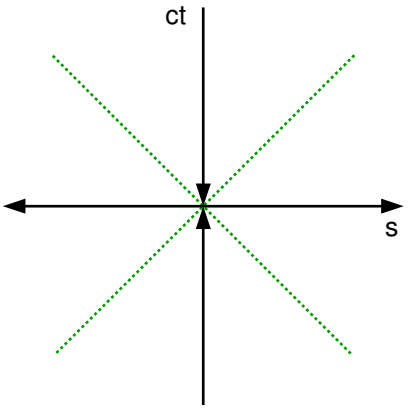


*Figure 3: Implicate order*

1 Just for the sake of information, the diagrams superpose more pair of axes – with different slopes – in order to represent different reference frames for different observers. For that same reason, in order to compare perceptible events with *c*, the "ray of light diagonals" should be depicted just a little bit sloped, tending to overlap over *s* axis.

2 Rossi (2019-2020: 34-36, 56) focuses on the past of "here and now".

3 The experience of somebody reading a simple text could fit an analogy in that sense. Reading these lines, my eyes catch one letter after the other, from left to right (from past to future): I think the words "Reading these lines…" to be part of my past experience because I just passed through them; but the following words – representing my future experience, relative to my frame of reference –

tent with the theories of Feynman (1949a) and Bohm (1980), as referred in the next chapter.

## 2. Inferences

The logic implied by the diagram in fig. 2 is consistent with 2nd law of thermodynamics[4]: irreversibility of natural processes – i.e. timeline developing from past to future only – relies on *entropy*, which is always increasing. But that depends only on our perceptions, just like the idea of future represents events still to come, but already occurred in the "past of the future" (like the example of the star in previous chapter).

Clausius (1864) coined the word "entropy" (from Greek *ἡ τροπή*, "the transformation") in order to summarize a seminal idea: the heat passes spontaneously from hot to cold bodies only, and that process keeps going on continuously, until bodies come to the same temperature (ideally); just like, according to Boltzmann (1877), gas molecules tend to move randomly in space, taking disordered and random configurations (e.g. all gas molecules ever exchanging position throughout a room), rather than taking ordered configurations (e.g. all the molecules gathered in one single corner of a room). Entropy means the incessant transformation of matter: molecules move around, bumping into each other, exchanging energy, generating heat by friction and bumps, tending to an equilibrium in motion and temperature, when each molecule would convey the same level of excitation.

Entropy assumes time as the "evolution" from ordered states to disordered states of matter: order in the past comes to be disorder in the future[5]. Therefor we can consider events as the "traces" of disorder. But "order" relies on the minds of observers of events; moreover, order relies on culture[6]. Time and order rely on the structure of mind, therefor time relies on culture: the nervous system, the body and the mind perceive time flowing from past to future only – then cultures organize representations of the time[7]; but te time itself seems to be a complex continuum of states, just like Feynman (1949a), Bohm (1980) and Bohm/Hiley/Kaloyerou (1987) suggested: the former explained the antiparticles (e.g. positrons) in terms of particles (e.g. electrons) moving "backwards in time", developing spacetime diagrams with bidirectional timelines, admitting top-to-bottom fluxes (e.g. the body in fig. 2 getting back to its original position, underneath the *s* axis); the others developed a theory of "non-locality", with ubiquitous particles in "implicate order" (a field of every possible state superposed to the other states) that our perceptions (viz. measurements) "actualize" to real states in "explicate order" (the common everyday life experience).

The diagram depicted in fig. 3 represents the implicate order of Bohm's theory: lower quarters collect past information – viz. memories – while upper quarters collect information still to come to our senses – but *already* existing. Every "here and now" the mind gathers information from the upper cone, and structures and retrieves memories in the lower cone: the "here and now" (the origin of axes) being a virtual construct

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are still coming to my eyes, being *already* in the text, which was just there before I started to read it. The same analogy could be applied to the processes of writing and thinking.

4 Rovelli (2017: 29-31) recapitulated explanations of time in terms of thermodynamics.

5 The Big Bang initiated that irreversible process.

6 Different cultures organize different criteria for order.

7 Rossi (2010/2018) gave an introduction to epistemology of Western time conception.

based on past (both the lower and the upper past in fig. 3). So that both timelines coexist just like one single loop: the tails are joined through infinity, while the arrows are joined in the point of "here and now".

The past and the future appear to coexist in regard to present time, as I stated in the previous chapter. That is an ancient conception in philosophy, as pointed out by Rossi (2019-2020); and that means that entropy – viz. 2nd law of thermodynamics – is caused by the structure of our mind, in terms of matter constituting our mind; because we experience entropy depending on the structure of our mind and our sensory system.

Bergson (1896) developed a theory of memory, which in facts is a theory of mind and a theory of experience. He suggested the "here and now" to be a single point, like the tip of a cone insisting on the frame – viz. the plane – of actual matter; the cone itself representing memories. I should rotate 180° the fig. 4, I would obtain a past cone of spacetime diagrams like the one in fig. 2.

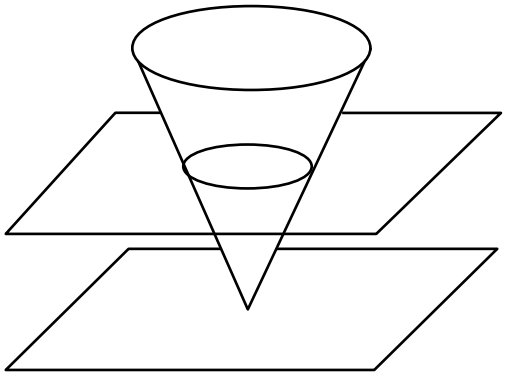

*Figure 4: Bergson's memory scheme*

Bergson's idea means that mind – which relies on matter – gathers information from the past, organizing an "image" of past configurations of matter itself; that meaning the mind "reads" that image, retrieving data (of the past, but in form of present matter) and actualizing data in new configurations of matter (of the mind).

That meaning the "here and now" ever depends on the past: because the "here and now" depends on the representation, the correlation and the interpretation of past data; just like Husserl (1928) and Patel (2008) explained about musical experience – but the same is true about every language indeed – which relies on (connections of internal representations of) memory of past sounds. The representation of past relies on brain matter, organizing itself in different configurations. That meaning we could define the past – and the future – like matter inaccessible to our senses here and now; and like (brain) matter configuring a representation of matter accessible to mind. That meaning the mind gathers sensory information – via the thalamus (for simplicity) here and now – then mind codifies that sensory information – in various neural networks – generating the cone of the past. That meaning a displacement represented in the past cone of spacetime diagrams (e.g. in fig. 2) represents memories, rather than actual facts; just like Bergson (1896) suggested.

The position of the cone in fig. 4, pointing its base upwards, is – casually – consistent with light cones of spacetime diagrams because the memory keeps building itself through time via configurations of brain matter: memories are still to come, configuring new neural patterns; every "here and now" builds up new memories on and on, but our awareness arises a little bit after each configuration.

Thinking every event relying on the past means that time and matter are bounded in a complex set, joining future, present and past events together in what Bohm (1980) called "implicate order": time axis represented in fig. 3 is a *loop*, with no beginning nor ending outside of our experience because time dimension relies (only) on our mind; and our mind and senses read single points in explicate order – and only in that order, regulated by 2nd law of thermodynamics, which follows the structure of our mind it-

self. Every single moment in time embraces all the space because time is relative to space and displacement, following Einstein (1905). All the space – all the unified field – identifies all the time at once, and all the time identifies all the space everywhere, like the twist in a Möbius strip occurs along all of the strip, rather than on a single spot of the strip.

Looping (or looped) time means constant matter because time relies on matter: infinite time implies infinite matter; and infinite entities are constant because they cannot be differentiated ($^{\infty}/_{n} = \infty$). That means constant information: all of the information gets bound together through chronotope[8], e.g. like a book keeps every of its word in a compact set, until our reading scans text through time (viz. through lines and pages), or like a disc (or a mp3 file) keeps all the data together, our hearing scanning music throughout of the medium[9].

Loops and information – loops of information – fill our experience and our body itself: DNA loops regulate existence of animals and plants. The metaphor of DNA loop[10] (fig. 5 top) illustrates a *Superposition Loop* (fig. 5 bottom), where an infinite number of variables or states (instead of nucleotides) loops around an infinite set (instead of static and finite sets in DNA). Every state gets superposed to other states (like *1–9* pair or *2–8* pair, etc. in fig. 5 bottom) as the string loops by, continuously shifting the superpositions between each variable; the "bends" make single variables actualize a state (e.g. position $\infty$ and position *5* in fig. 5 bottom), disconnecting them variables from the system of superpositions, in order to establish new superpositions (e.g. next step in the loop of fig. 5 bottom should make state *4* collapse, in order to superpose states *5–3*, *2–6* and so on); the "bends", collapsing variables, identify (infinite) polarities on opposite sides of the loop. Every state gets superposed to other states via the continuous "position exchange" or, in common terms, "looping around" the implicate order – not via the loop itself, which is just an ideal construct for us (in explicate order) to grasp a complex structure.

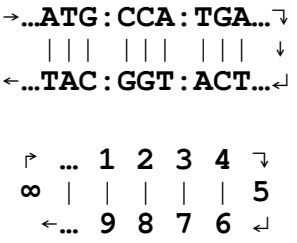


*Figure 5: DNA loop and Superposition Loop*

Time – in the non-local frame of interpretation – is the order we perceive variables collapsing through explicate order. But "order" is just a concept, a state of mind, a pattern, as variables in implicate order could be collapsing altogether at once, as long as they could remain superposed one another, never collapsing at all.

However, question is what *variables* or *states* are or mean, for Superposition Loop is just a logical construct built out of our intuition: the Superposition Loop is just an-

8 Rossi (2019-2020: 106) described black holes like holograms, in the terms of Susskind (1995) and Susskind/Lindesay (2005), where every bit of information flows throughout the surface of a black hole, gathering information from outside universe and extruding information within the black hole itself, with every single bit identical to each other single bit, all of them conveying every information about the whole black hole.

9 Book and disc metaphors could imply superdeterminism – for Big Bang predetermined every state of experience – but quantum mechanics' idea of *superposition* implies every possible state superposed to others, thus every possible "book" superposed to other books, collapsing by chance in one's experience throughout a specific timeline (parallel with different timelines), as Bohm/Hiley/Kaloyerou (1987) and Rossi (2019-2020: 68) pointed out. Fig. 3 represents that interpretation of superposition: all the (possible) space (along *s* axis) gets caught throughout all the time (along *ct* axis) collapsing in a single point.

10 Annunziato (2008) clarifies how DNA packaging organizes information in looping structures. One string of Adenosine (*A*), Thymidine (*T*), Cytidine (*C*) and Guanosine (*G*) assembles a loop of biologic information (twisted in the double helix shape), organized in triplets.

other representation of the unified field – variables or states meaning "quanta" – entities we need to represent in order to think of time and, moreover, to feel time.

## 3. Interpretations

Planck (1899), having introduced quantization of physical entities, also introduced *natural units* of measurement defined in terms of universal constants: that way one can define events in terms of minimal-universal-natural units, consistent with every human experience, on the basis of the speed of light ($c$), of the gravitational constant ($G$), of the reduced Planck constant ($\hbar$), of the Boltzmann constant ($k_B$), and of the Coulomb constant ($k_C$). "Natural" units sign the landmark between commensurable experience (viz. subatomic scale) and theoretical structures of nature (viz. quantum scale). Planck length ($\ell_P = 1.61625\times10^{-35}$ m) is the minimal wavelength of a free photon in space, for a shorter wavelength the photon collapses to a (massive) black hole. Planck mass ($m_P = 2.176434\times10^{-8}$ kg) is the mass of radius $\ell_P$ (that suggesting indirectly photon as a massive entity). Planck temperature ($T_P = 1.416784\times10^{32}$ K) is the highest temperature limit in quantum physics. Planck charge ($q_P = 1.875545\times10^{-18}$ C) is the minimal electric potential energy of $m_P$. Planck time ($t_P = 5.391247\times10^{-44}$ s) is the time that a wave travels the distance $\ell_P$ at the speed of light, that meaning:

$$t_P = \frac{\ell_P}{c} \quad \rightarrow \quad t_P = \frac{1.616\,255\times10^{-35}\,\text{m}}{299\,792\,458\,\text{m/s}} \quad \rightarrow \quad t_P = \frac{1.616\,255\times10^{-35}}{299\,792\,458}\,\text{s}$$

"Natural" equations define time in terms of space, just like spacetime diagrams correlate space ($s$) to time-space ($ct$), and just like (in general terms) globalized culture defines time in terms of space[11].

Whenever we think of $t_P$ as of the minimal possible transition of states in the Superposition Loop (fig. 5) or in the unified field, we think of (some minimal) differentiation in space: the general idea of "looping" implies motion and momentum; whereas total fluidity could coincide to perfect immobility[12]. Time means a differentiation occurring in our perception only, thus in the structure of our perception and mind[13]; whereas the unified field could imply a compact – motionless – set of information, putting it in the terms of Bohm (1980). *Differentiation* or *change* is what we experience and what we perceive in our life (in our mind), "change" for physics meaning "motion", "momentum", "speed", "acceleration", and "mass": the fundamental chronotope entities.

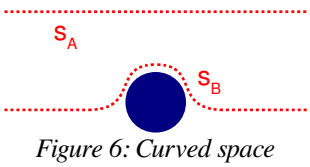

*Figure 6: Curved space*

Einstein (1905; 1916), speculating on spacetime entities and mass, explained how the time accelerates in outer space, away from bodies, while it decelerates near to bodies: larger bodies slow down time – they lessen the available time – because mass bends the space around the mass itself[14]; therefor outer space (e.g. some distance $s_A$, called *null geodesic* in spacetime lexicon) "gets stretched" in the proximity of a body (*geodeisc* $s_B > s_A$), as it is sketched in

11 Rossi (2010/2018) analyzed the epistemology of time in globalized popular culture.

12 E.g. black holes capture light accelerating it over $c$: a velocity that our perception guesses as "nothing", for no motion at all (no light perceived).

13 Matte Blanco (1967) explained conscious perceptions in the perspective of differentiation, and unconscious mind in the perspective of symmetry.

fig. 6, so that it takes more time for light to travel the "stretched distance" ($s_B$) rather than the "straight one" ($s_A$), traveling at its constant velocity ($c$). "Time-near-the-mass" ($ct = s_B$) is worth less than "time-away-from-the-mass" ($ct = s_A$) all along the geodesics.

A "stretched distance" means more space than a "non-stretched distance", that meaning more $\ell_P$ units compose $s_B$ than $\ell_P$ units composing $s_A$; the same way, more time means more $t_P$ – the same idea applying to "less time" and "less space" circumstances. That meaning: mass creates and erases spacetime from nothing, just like Feynman (1949a) explained the sudden creation and annihilation of particles (mass) in terms of spacetime diagrams[15]. Thus, we can think of motion as of matter erased from a position in spacetime *and* matter created to another position in spacetime: all the matter exists superposed throughout all the chronotope, for matter keeps transforming itself, rather then being created or erased – annihilated – on the basis of the principle of mass conservation, from Empedocles (4th cent. BC) to Lavoisier (1774)[16].

Time relies on matter; and matter implies gravity.

Gravity affects time as a consequence of space dilation: the mass bends the space around itself, and curved space pushes smaller bodies toward greater masses[17]. However, black holes reverse that condition: light cannot escape from black holes, due to the singularity (the mass) within the Schwarzschild radius (1916a; 1916b), because the gravity inside black holes accelerates everything over the speed of light – otherwise light could escape the event horizon and we should see inside of a "non-black hole". That way, time stops along the event horizon of black holes because, in terms of Lorentz (1904) and Minkowski (1909: 80), time dilation ($t'$) approximates infinity:

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \rightarrow \quad \infty \approx \frac{t}{\sqrt{1 - \frac{c^2}{c^2}}}$$

Along the event horizon the time stops because light keeps radiating through space, but light never covers enough distance – in enough time – to escape the gravitational field exerted from the singularity: gravity creates infinite space, erasing time. While, inside the black hole, time dilation implies twofold values ($\pm t'$) because of the increasing velocity ($v > c$):

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \rightarrow \quad \pm t' = \frac{t}{\sqrt{-\phi}}$$

14 Dyson/Eddington/Davidson (1920) proved how a mass bends the space around itself, affecting the path traveled by light, like Einstein (1916) stated.

15 A common experience provides the evidence for the creation of matter from apparently "nothing": a green seed blooms a root and a sprout, growing a tree. DNA provides all the information necessary for the seed to anchor itself to the soil via the roots and to extract carbon from carbon dioxide gathered from the air. The *mass of the tree* (wood and leaves) comes from the *mass of the resources* (water and carbon molecules left over from photosynthesis) gathered through time from the air by the leaves (Blankenship 2002).

16 I am aware that quantum physics implies creation and annihilation of field quanta, but that is exactly my point: time cannot be created or annihilated (as long as we observe variables collapsing through), thus space and matter cannot be created or annihilated – time relying on space.

17 De Pretto (1904: 9-24) stated that principle. Rossi (2019-2020: 51-53) explains the meaning of De Pretto's intuition in comparison to Einstein's relativity.

The square root of a negative number implies superposed values ($\pm t'$) – implying the imaginary unit ($i = \sqrt{-1}$) – thus meaning the past and the future develop altogether, operating a destructive interference and annihilating each other: matter exists in a compact set of superpositions.

We can look into two alternative interpretations of that circumstance: (1) the light keeps displacing on and on, both toward the event horizon and toward the singularity, never covering the full distance out of the event horizon (sort of Zeno's *Achilles and the tortoise* paradox), keeping its momentum *ad infinitum*, so that there a single fraction of time stands for all the time ($t = \infty$); (2) the light stops displacing ($s = 0$) and the time stops flowing ($t = 0$), with no possibility for motion (sort of Zeno's *arrow paradox*)[18]. Thus – at least inside a black hole – paste, present and future should be superposed one another, thus (all possible states of) matter should be superposed too.

On the other hand, even the properties of light in outer space (viz. light-out-of-black-holes) provide clues about (inferences on) superposition of matter: the light – every photon – emitted from a star escapes the gravitational force exerted by the star itself, for the energy supplied from the star in emitting the photons ($E = h\lambda$) exceeds the gravitational force ($F = {}^{GMm}/_{rr}$) exerted by the mass of the star ($M$) on the mass of each photon ($m$)[19]. That inference should fit whether considering the photon ($\gamma$) a massless entity ($m_\gamma = 0$ implies $E > {}^{0}/_{rr}$) or considering the photon a massive particle[20] ($E > {}^{GMm}/_{rr}$ implies $m_\gamma > 0$). The massless case implies the impossibility for the photon to occupy any space, for mass must occupy spacetime[21], while it implies *the photon itself to radiate spacetime itself* (Rossi 2019-2020: 164-165), along with what Maxwell (1865: 466) stated: that meaning the photons superpose throughout all the chronotope, superposing every location in space and every location in time (viz. *non-locality* meaning "total-locality" or omnipresence). On the other hand, the massive case implies that, for special relativity, velocity shortens or compresses matter, so that mass of photon – traveling at the highest possible velocity limit ($c$) – gets to the highest possible shrinking limit: that suggesting, conversely, bigger mass of slower photons, and maximum photon mass of photons at rest. Nevertheless, evidences show a photon cannot be stationary (at rest): its momentum is always $p_\gamma > 0$ because the photon always travels (in vacuum) at the speed of light ($c$)[22]; thus the momentum of a photon is also *indeterminate*, because in general relativity (both for $m_\gamma = 0$ and $m_\gamma > 0$):

$$p_\gamma' = \frac{vm_\gamma}{\sqrt{1-\frac{v^2}{c^2}}} \quad \rightarrow \quad p_\gamma' = \frac{vm_\gamma}{\sqrt{1-\frac{c^2}{c^2}}} \quad \rightarrow \quad p_\gamma' = \frac{vm_\gamma}{\sqrt{0}} \quad \rightarrow \quad p_\gamma' = \frac{vm_\gamma}{0}$$

18 Aristotle (VI: 9) illustrated both paradoxes.

19 Photons are affected by gravity (Einstein 1916; Dyson/Eddington/Davidson 1920) for they travel along geodesics (fig. 6) and they convey energy: $E$, spent by a photon to defy the gravitational pull ($F$) of a body, reduces the photon's wavelength ($\lambda$) according to the *gravitational redshift* effect (Einstein 1907; Adams 1908), for the light shifts toward the red (viz. weaker) part of the spectrum.

20 Feynman (1949b), Greiner/Reinhardt (1986/1993: 152) and Tu/Luo/Gillies (2005), among others, speculated on massive photons: the latter record (from experiments in literature) $m_\gamma \approx 5\times10^{-42}$ g or $m_\gamma \approx 3.4\times10^{-44}$ g or $m_\gamma \approx 3\times10^{-45}$ g or $m_\gamma \approx 8\times10^{-48}$ g. Anyhow, the photon rest mass results way less worth than Planck mass ($m_\gamma < m_P$): keeping widening the horizons of subatomic structures and theoretical physics, we fit experience with radical idea set out by Mandelbrot (1975; 1980), according to whom one will always find out a smaller scale of reference for natural structures (Rossi 2019-2020: 107-110).

21 Electromagnetic radiation itself – thus electromagnetic filed – displaces massive particles, like electrons, interacting by the mediation of photons (Rossi 2019-2020: 164-165; Maxwell 1865).

22 Photon travels with velocity $c$ even in regard to relativistic bodies approximating $c$.

Momentum ($p_\gamma$) of the photon is everything and nothing: it is a superposition state, generating *and* erasing time, as long as gravity and speed generate *and* erase space.

## 4. Remarks

Our common experience of space and time – viz. past events flowing toward future or, in other terms, past events evolving into future events, which idea regulates the cause-effect principle – relies on matter states for two reasons at least: (1) our mind and consciousness are matter-based constructs, which patterns give rise to perception and experience[23]; (2) matter – mass – modifies chronotope patterns (viz. geodesics), pointing mass itself toward specific directions in spacetime (e.g. the way light displaces inside or outside a black hole).

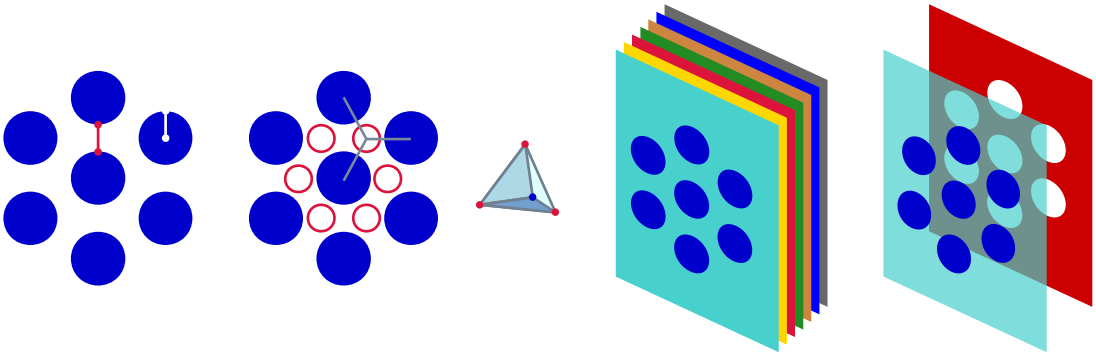

*Figure 7: Quantum field lattice*

Nevertheless, theoretical physics and philosophy suggest the radical idea of an *unified field*, superposing matter, charge and time in quantum continuum[24] – an *isotropic vector matrix*[25], for simplicity of representation we can think of as a 3-dimensional raster in the shape of a tetrahedron lattice: $\ell_S$ (on $X$ and $Y$ axes, like the first two sketches in fig. 7) and $ct_S$ (on $Z$ axis, where the lattice identifies different layers, like the last two sketches in fig. 7) separate every quantum ($q_S$, $m_S$ with radius $\ell_S$) from its closer neighbors (along the 3 axes), on the basis of the quantization principle, for there must be a minimal (quantum) scale ($\ell_S$) of chronotope. Every quantum superposes collapsed (null charge) states ($q = 0$) on active states ($q = q_S$), that way every group of 3 nearby quanta in a layer connect an equidistant quantum on the previous and on the next layer (like the second sketch from left in fig. 7)[26]. In every layer, clusters of active

23 Dietrich (2003), among many others, localized brain areas and neuronal features involved in altered state of consciousness, assessing how perceptions vary on the basis of configurations of brain matter. Penrose (1994/2005) and Hameroff/Penrose (2014) suggested the quantum structure of mind and consciousness as the reason we perceive reality as it is. Apart from those considerations, we should reckon the basis of relativistic physics are bound to perceptions: Lorentz (1904) transformations imply that length contraction and time dilation occur *in the experience* of the person who measures time or length in regard to some relativistic frame – so that relativistic transformations occur as phenomena in the experience (of the mind) of an individual. All the relativity theory should be assessed like a cognitive theory for the mind.

24 Greiner/Reinhardt (1986/1993) delve into the mathematics of field quantization.

25 Buckminster Fuller/Applewhite (1975: 500) developed radical concepts on that topic.

26 "If you want to envision a quantum as a dot then you are trapped" (Zukav 1979: 262). That is exactly the reason why we can imagine the unified field like a 3-dimensional lattice arranging layers of 2-dimensional lattices: a quantum can be a particle (a dot) on a single layer, but that quantum itself can be a wave oscillating in time through layers (i.e., layer by layer, one quantum connects to its

quanta ($m_S$, $q = q_S$) define complex states of matter (like quarks, atoms, molecules etc.) displacing in time (along $Z$ axis, layer by layer) on the basis of activation and collapse ($m = 0$, $q = 0$) of quanta.

The quantum lattice is defined on the basis of (arbitrary) submultiples ($S$) of Planck units (e.g. $t_S$ rather than $t_P$)[27] as a frame of reference, because theoretical physics recognize the possibility to identify ever smaller scales of reference (as technology develops new standards of observation and measurement[28]), following the idea of recursive natural patterns stated by Mandelbrot (1975: 1980): thus we can think of a *tomic model*, rather than the current atomic and subatomic models – gr. verb τέμνειν ("to cut", "to divide") meaning we can scale down every (newer and smaller) frame of reference, in a fractal perspective[29]; whereas the *a-tomic* and quantum models come from the idea of some indivisible unit, which appears to be just a convenient analytical limit for observations.

The tetrahedron lattice (fig. 7) arranges layers[30] of quanta ($q_S$, $m_S$), distant $\ell_S$ one another: every layer of quanta represents space in time (just like $ct$ axis in fig. 3), so that the whole lattice represents the quantum field in a single "here and now" moment, with a specific layer representing the frame of reference of the observer – all the other layers pointing toward the reference layer of the lattice; all the layers superposing one another, just like each point of the lattice represents a superposition of states ($q = 0$, $q = q_S$).

That recursive "confusion" – viz. superposition – of states could give rise to unstructured and ever-changing configurations of matter, rather than structured and well-stable configurations we experience in common day life[31]: nevertheless we perceive reality as the result of a unified field giving rise only to specific patterns of activation and collapse – the patterns included in the "horizon" of light cones (fig. 2 and fig. 3) – which are legitimated by the ($\ell_S$ and $ct_S$) connections between quanta (viz. nodes) and layers of the lattice. That meaning collapsed quanta ($m_S = 0$, $q_S = 0$) allow only specific patterns – or connection between neighbor quanta ($q_S$, $m_S$) and layers – through the lattice: reason why the potential chaotic structure of superposition collapses into stable states of matter.

For the quantum field arranges quanta or minimal charges ($q_S$), the photon ($\gamma$) could be the result of quantum activation and collapse throughout the lattice, as long as any other elementary particle ($q_S$, $m_S$) arises from clusters of quanta arranged through the lattice. The peculiar property of the photon (its constant velocity $c$ for any frame of reference) implies the photon does not displace through the lattice, whereas the lattice itself consists in a potential arrangement of photons along all of the structure (viz. superposition principle). That remark could explain a seminal point in relativity: Einstein (1916) assumed the photon displaces at the speed of light ($c \approx 299792$ $^{Km}/_{s}$) even in reference to frames displacing at speeds approaching $c$ – viz. I should travel at $v \approx c$, still I would see the photon displacing at velocity $c$. The photon could be thought of as an entity of immense radius ($r_\gamma \approx 299792$ Km), rather than an infinitesimal massless

time-relative via one diagonal side of the $Z$-axis face of the tetrahedron, as depicted in the second sketch of fig. 7).

27 The unit $t_S$ is the time that a wave travels the distance $\ell_S$ at the speed of light (just like $t_P$).

28 For instance, quarks have $q = {}^{1}/_{3}$ e, way less than the minimal electric charge ($q = 1$ e) .

29 Rossi (2019-2020: 91-111) delves into epistemology of fractals in physics.

30 $X$ and $Y$ axes of the first two sketches in fig. 7 generalize 3-dimensional space; while $Z$ axis generalizes the order of $ct_S$. Moreover, $ct_S = \ell_S$ because $ct = ({}^{\ell}/_{t})t$.

31 Similarly, altered states of consciousness rely on specific neuronal – thus molecular, thus atomic – patterns (Dietrich 2003).

particle ($r_\gamma = 0$). Relativity implying space related to time, the length $r_\gamma \approx 299792$ Km implies 1 s as a frame of reference in our cognitive experience: but the quantum of our cognitive experience (viz. the minimal fraction of information perceived or processed by consciousness) is smaller than 1 s – 0.005 s, according to Eagleman (2009)[32] – that way the photon would be an entity of $r_\gamma \approx 299.79$ Km (for 0.001 s quantum perception). Moreover, $c \approx 299792$ $^{Km}/_{s}$ in vacuum implies $c < 299792$ $^{Km}/_{s}$ in any other medium or (in other terms) when the photon interacts with mass – as long as mass dilates spacetime, mass stretches $r_\gamma$: reason why light gets slower within a medium rather than in vacuum. The photon being a *wavicle*[33] (viz. a wave *and* a particle), the photon in the lattice (of fig. 7) would be a sphere of $r_\gamma \approx 299792$ Km along a number of layers sufficient to sum up 1 s; but $r_\gamma$ (and the volume of $\gamma$) should shrink down as the observer limits the observation to a minor number of layers, down to the quantum level ($q_S$, $m_S$) for a single-layer-observation.

## Conclusions

Perception always occurs in regard to past events: *present* is the aware perception of past events. Present time is a virtual state of mind established on events located out-of-the-mind, in some frame of reference different from our subjective position in chronotope. Moreover, we live both in the past and in the future altogether: we live in the past because our "present" perceptions arise (some $t_S$) after our mind processed information gathered from events occurred some $t_S$ before our awareness; *and* we live in the future because events perceived by our body (and mind) occur from ahead (or from above in fig. 1 and fig. 2) of our subjective timeline[34], relatively to our "virtual present" location. Therefor the future is a different state of the past (fig. 3) because what we consider future events – in regard to our perceived position within our timeline – are events already happened (some $t_S$ before perception): real events occur out of our perception; and awareness (through perception) translates those events in a virtual construct[35] we call *consciousness*. That meaning time differentiation is just the way our mind (viz. a set of unified field states) represents a very complex reality, which seems to consist in a compact set of superposed information[36] (like information theorized to be gathered along the surface of black holes[37]).

Displacement and speed (two fundamental events analyzed in physics) mean information only in regard to perceptions – while perceptions themselves consist in matter: quanta displace through chronotope, structuring our brain, giving rise to processes in our mind, defining our awareness. Consciousness is the interaction of events occurring in chronotope – rising from unified field lattice configurations (fig. 7) – thus consciousness is a subset of the lattice: consciousness is a differentiation – a partition – in unified field, where time lies compact and undifferentiated as long as space does, as long as matter does. Schopenhauer (1819) came all along the way.

32 "Two visual stimuli can be accurately deemed simultaneous down to five milliseconds, and their order can be assessed down to twenty-millisecond resolutions".
33 Eddington (1928: 201) coined the term.
34 Bodenhamer/Hall (1999: 353-380) explained the ways people represent time in their minds.
35 Rossi (2019-2020: 141-151) explained that idea.
36 Among others, Fantappié (1944), Feynman (1949), Matte Blanco (1975), Bohm (1980), Penrose (2005) – from different perspectives and in different ways, they all account for a compact, undifferentiated structure of the whole.
37 Susskind (1995), Susskind/Lindesay (2005), Rossi (2019-2020: 105-111) speculated on that topic.

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