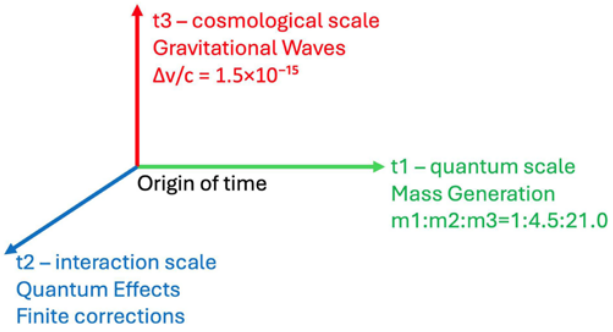
The three dimensions of time, gravity, and entropy



It is risky to talk about new physical theories, as there are far too many that we will never hear about again, and it must be said that the January article "*Three-Dimensional Time: A Mathematical Framework for Fundamental Physics*" seems a little too bold, postulating not only 3 dimensions of time, which is already difficult to swallow, but above all that the three dimensions of space and particles are produced by the interaction of these **three different forms of physical temporality**. This is not entirely new, as there were already reasons to believe that the parameter ***t*** representing time must have three components: t_x, t_y, t_z (verifying $t^2 = t_x^2 + t_y^2 + t_z^2$). Here it is different but no less surreal and difficult to imagine. The article is published in a minor peer-reviewed scientific journal (*Reports in Advances of Physical Sciences*). However, there has not yet been any real criticism of this latest attempt to unify physics on entirely new foundations. The mathematical framework has the advantage of preserving **causality** and claims to predict the properties of different generations of particles and to **reproduce their masses**. All this remains to be verified.

Without claiming to have any opinion on its validity, what interested me was that this theory was in some ways similar to the tripartition I emphasized in a 2021 text (Quantum determinism, entropy, and freedom) between **quantum, classical, and cosmological physics**, which do not obey the same laws and are distinguished above all by their distinct time scales. Even if I am not really convinced, its interest lies in identifying reality with time itself, like Lee Smolin and in contrast to almost everyone else who considers it a given illusion (in a space-time block). This theory has at least one great power to disorient, renewing the question of temporality, its origin, and its irreversibility, giving me the opportunity to question the place given to entropy, improbability, and the arrow of time.

The three times: the dynamics of the universe

The model distinguishes three dimensions of time, time not being a single axis, but a **structure with three independent dimensions** [which seem to be well nested, at least], differentiated by **physical scale and function**:

- **Quantum time**: at the Planck scale, it produces the fundamental constants and the three generations of particles as well as their mass via the three eigenstates of the resonant structure of this temporal field. It operates in the realm of fluctuations, resonance, and indeterminacy. Its non-deterministic behavior, dominated by fluctuations, constitutes the dynamic basis of reality.
- **Classical time**: this is local time, the time of measurements and events. It carries causality and human perception of the succession of events (but does not contain any directional arrow within itself, as it is assumed to be reversible!).
- **Cosmological time**: very slow but irreversible directional time, with a large amplitude, on the scale of the universe — **carrier of the cosmic and gravitational structure**. It structures

the universe on a large scale, regulating its expansion, curvature, and the overall conditions of its evolution. Gravity, and more generally the gravitational curvature of general relativity, would result from the **dynamics of cosmological time**, which allows gravity and cosmology to be geometrically unified with particle physics. However, this would not be the time of causality but of the form of space-time, of the evolution of the universe, a geometric constraint, not a chain of events. More surprising (but as in the standard model) is that it would nevertheless be the origin of entropy growth through its asymmetry that would make possible the irreversibility observed in classical time (!!) and constitute the **arrow of time**.

The article proposes that **three-dimensional space does not exist in its fundamental state**, but arises through the **mathematical transformation of two temporal dimensions**. A symmetry break between these three temporalities—equivalent at the outset—would produce a **global metric** linking them in a common mathematical space. This metric field would then give rise to **three degrees of spatial freedom**—in other words, the **emergence of three-dimensional space**. Space is no longer a given, but a **structure derived** from temporal complexity, a **mathematical residue** of these three times. The conventional notions of space and time thus become **emerging phenomena** at a more fundamental level.

Discussion

I'm not at all sure that my understanding (aided by ChatGPT) is sufficient, but that's not my real subject, rather the questions raised by the reduction of physics to temporality. While the distinction between different temporalities deserves attention, the emergence of space is much more enigmatic, but this attempt to establish a temporal foundation for physics is above all an opportunity to challenge the accepted assumptions about the orientation of time and the origin of entropy, rejecting in particular the supposed reversibility of time as well as the origin of the arrow of time, which is supposed to come from the low entropy of the Big Bang, whereas it should be attributed to gravity in a much more dialectical entropy.

1. The irreversibility of the arrow of time

Mathematically, a time axis has no arrow: it is symmetrical (as in classical mechanics or Schrödinger's equation). Classical laws (such as Newtonian mechanics or even general relativity locally) are assumed to be reversible.

In this article, there is an ambiguity about the origin of the arrow of time, which is first attributed solely to cosmological time and then made an emergent phenomenon of their interaction, the result of the combination of the three times. It should be said more precisely that **the arrow of time** results from a **global irreversibility effect**, induced by **cosmological asymmetry**, structured by **quantum dynamics**, and **manifested locally** in **classical time.**

The arrow of time would therefore be the combined effect of:

- quantum **indeterminacy** (decoherence, collapse of the wave function), which introduces **irreducible fluctuations** at the Planck scale (but not an arrow of time).
- **classical causal perception** (but assumed to be reversible!).
- and above all **cosmological asymmetry** (increasing entropy, expansion of the universe). The universe is evolving from an extremely dense and hot state (big bang) to a cold, diffuse, dilated state. This evolution **gives a macroscopic direction** to time: **from low entropy to**

> **high entropy**. To escape reversibility, the **thermodynamic arrow** (growth of entropy) would thus be based on the **initial asymmetry** of the universe, and therefore on the structure of cosmological time.

In other words, what we experience as an irreversible succession is not an immediate given, but a local projection of a larger temporal structure. It seems strange that thermodynamics, which is omnipresent on our scale, could depend on a global cause, but the most absurd thing, although commonly accepted, is that quantum and classical time can be considered reversible, requiring cosmological time to orient the arrow of time! It would have been understandable, however, that it would be the breaking of temporal symmetry that would have given a privileged meaning to classical time, that of the “passage” of time, where the arrow of time is indeed that of the sequence of causes.

It is clear that, **at our scale**, we observe **irreversibility**: heat diffuses, gases mix, organisms age, and more generally, **entropy increases** (second law of thermodynamics).

It is completely incomprehensible to claim that the real irreversibility we observe (broken eggs, dissipated heat, biological death) could be linked to an increase in global entropy and entirely determined by the very specific initial conditions of the universe (very low entropy of the Big Bang). It is purely by dogmatic deduction that we refuse to attribute **the arrow of time** to classical causality or to local heat differences, clinging instead **to the asymmetry of cosmological time** and the postulate that the system must **begin in a state of low entropy**.

We would have to accept that:

- Physical laws are **reversible**,
- The growth of entropy comes **from a highly improbable initial state of the universe**,
- Entropy does not depend on local laws but on **cosmological time**, providing **the condition of possibility** for increasing entropy.

In fact, physical equations could only be reversible if they were complete, without any remainder, knowing neither chaotic indeterminacies, nor non-linear phenomena, nor external perturbations. The reversibility of time itself (general reversal of all speeds) is something else entirely and a pure mathematical (cinematic) illusion, the privileged domain of science fiction. As soon as we talk about measurement or interaction, there is irreversibility. The true arrow of time is that of the order of causes (the expansion of the light cone), of which the increase in statistical entropy is an integral part, as a tendency to return to the most probable state when nothing prevents it. The link with the universe is quite problematic, apart from the fact that this temporality is necessarily included in cosmological time.

2. The problem of initial entropy

Beyond this particular article, the dominant view nevertheless assumes that the universe began in a “low entropy” state, but we would still need to agree on its level—supposedly highly ordered or even minimum entropy—which is what is supposed to allow the arrow of time to appear through simple statistical evolution, but above all to constitute all the entropic capital available for the future. This hypothesis is problematic because it merely assumes what it is supposed to explain. More generally, as I have written, "*Entropy is one of the most fundamental concepts in physics. However, it is poorly understood. Consider that minimum entropy can be attributed just as well to absolute zero, which freezes all movement in a heat death, as to the maximum heat of the Big Bang*

before its inflation dispersed it throughout the universe."**Maximum entropy** is also impossible to define without contradictions, even if we try to limit it to a maximum amount of energy per surface area. We would like to make black holes the objects with maximum entropy (via the Bekenstein-Hawking formula), even though we are in a situation of concentration close to that of the Big Bang, which is claimed to have minimum entropy! Worse still, if we think that the universe could be cyclical or come from a black hole (which became a white fountain in a new Big Bang), the contradiction is clearly impossible to resolve, since the maximum entropy at the end of one universe would have to be the minimum entropy of the next...

Let us repeat that it is purely on principle that current cosmology assumes that the arrow of time comes from an **initial condition of low entropy**: a young, homogeneous, isotropic, high-density universe, but one that is "ordered" and therefore offers **entropic potential to be dissipated**. Except that **this condition is posited, not explained**. Why would the universe have begun in such a state of maximum order, which would constitute an extremely improbable thermodynamic "chance"?

- It **assumes what it must explain**: why such a state of initial order?
- It makes entropy **a given**, when it should be an effect.
- It does not account for the **complex structure of the real world** (stars, molecules, biospheres).

There is no physical explanation for the logical necessity of a low-entropy beginning, and I find it difficult to accept Penrose's view that, despite its extreme energy and density, the initial state of the Big Bang would be of **minimal entropy**—what Penrose calls an "**extraordinarily ordered initial condition"**—on the pretext that it would be remarkably homogeneous with **very low gravitational entropy**, i.e., weakly gravitationally curved (one wonders why, when we say exactly the opposite of black holes). Furthermore, the **development of gravitational structures** is supposed to **increase this gravitational entropy**, whereas gravity, far from producing uniformity, **amplifies differences**. Under the effect of **gravitation**, the universe does not tend towards uniformity at all, but towards **differentiation**, **structure**, **progressive complexity**! To claim that gravity increases entropy stems from the assumption that everything is decided at time zero, determining the fate of the universe with a capital of entropy that allows it to evolve from a highly improbable state **evolving** towards more probable states. However, the only improbable feature of the origin of the universe is the concentration of its energy, which spreads out into space instead of being confined to a black hole. Otherwise, the supposed initial maximum order appears, on the contrary, as a disorder of agitated particles, and its role is obscure in the growth of ordinary entropy, which is clearly imposed by **local** (statistical) laws and not cosmological ones. Thermodynamic entropy belongs to our classical world, where it is an **effective** law on our scale.

Of course, for entropy to increase, there must be a state of lower entropy, but this is not necessarily the initial state; everything is already there, and can instead be **produced** by gravity, which is not merely anti-entropic by concentrating matter, but at the same time produces complex molecules that then seed the planets, providing them with a kind of entropic capital to spend. Otherwise, all existence, all matter, would be improbable in relation to an entropic universe that does nothing but disperse.

3. Gravity as a producer of negative entropy

The fashion is rather to make gravity an **emergent effect of entropy**, as in Erik Verlinde or in holographic theory, whereas I believe exactly the opposite: gravity **is not a side effect of entropy**, it

is **what makes entropy possible** because **gravity produces order**, which then allows entropy to grow locally. This does not mean, however, that we should follow Hawking in making gravity a **negative energy** balancing **positive energy (matter)**, which would allow the **total energy of the universe to be zero**, thereby enabling, through this sleight of hand, **creation ex nihilo** without violating the law of conservation!

This is a fine example of syllogism and purely dogmatic deductions. The question of creation from nothing is necessarily a paradox; there is always something, a void that is not so empty (Casimir effect), and associated laws, which could be gravity, not before the creation of the world, but at least before the creation of matter.

The idea that **gravitational energy** can be described as **negative** is based on the fact that the formation of a cosmic system (galaxy, star, etc.) **decreases the total potential energy**. However, this "negative energy" is **poorly defined overall** in general relativity (no universal conservation of energy in dynamic space-time).

In fact, I believe this reflects the common **confusion between energy and entropy**, as gravity can be seen as negative entropy producing order rather than negative energy (which is not the same thing). Negative energy would cancel out positive energy, whereas negative entropy opposes entropic dispersion, not as its abstract opposite, but rather as its generating moment: in a gradual and even very slow process, allowing time to leave its mark and build up entropic capital that will then be dispersed by star explosions, complex molecules that will be the starting point and fuel for entropic processes elsewhere. Gravity is a factory of differentiation and complexity for future evolution, which may be subject to increasing local entropy. There is no annihilation of energy, but rather an entropic construction/destruction marked by critical transitions (collapses, mergers, explosions). In this sense, it can be said that gravity **precedes** and **enables** local entropic processes through its anti-entropic function and as a source of improbable complexity in a world where the dominant trend is toward dispersion. The very existence of stars, carbon, terrestrial planets, and life is **highly improbable** in a homogeneous, gravity-free, entropic universe.

Whereas:

- Gravity **opposes dispersion locally**, **amplifies deviations from equilibrium, concentrates**, **organizes**, **structures**: it **creates improbable structures** (stars, heavy chemistry, planetary systems), **pockets of density and complexity**.
- These complex structures are not passive residues, but **reservoirs of entropic potential**, a locally usable **capital of order** that **seeds open systems** such as biospheres.
- This capital becomes the **condition for a second entropic cycle**: work, heat dissipation, wear and tear, decomposition, etc.
- It is only **thanks to these ordered structures** that local entropy can grow and find an organized medium to undo, and it is gravity that **creates these mediums** in stars.

4. Gravity as the arrow of time

Contrary to the standard interpretation based on initially low entropy, there is reason to believe that it is the production of improbable order—driven by gravity—that embodies true irreversibility.

In this framework, it is not the initial order and cosmological asymmetry that underpin the arrow of time, but rather **gravity**, by **organizing matter**, which generates entropic capital that is then dispersed. Gravity **creates the conditions for the possibility of an entropic world** by generating

reservoirs of ordered energy (suns, molecules, chemical gradients, etc.). The universe was not born ordered; it became a **source of order** through an **internal organizing force** (gravity). Rather than the low entropy of the initial order establishing the arrow of time, it is because gravity **generates improbable structures** that there can be **local growth of entropy**, with this production of order and complexity produced by gravity constituting the entropic capital that can then be spent at the classical thermodynamic level, and thus making entropy observable, **making time an irreversible river** full of surprises.

The growth of **classical** entropy does not explain the structure of reality; it is **the other way around**: **the structure of reality (matter, form, gravity)** is what makes the possibility of measurable entropy intelligible. This reverses the perspective: it is not so much **entropy that is universal**, but **the formation of organized matter** that is a **cosmological anomaly** to be explained, and which invites us to recognize another "law" of time: that of **improbable complexification**, **the emergence of forms**, **the deviation from the probable**. There is not only a destructive entropic time, there is also a constructive time where the complex builds on the simpler that came before it. This is perhaps where the true arrow of time ultimately lies, an arrow of time that does not fall from the sky but springs from matter that structures itself and evolves into a succession of improbable events.

Thus, the arrow of time becomes the effect of a **dynamic dialectic** between:

- primordial entropy,
- organizing gravitation,
- and the evolution of structures capable of becoming more complex.

5. Dialectical, non-linear, non-arithmetic entropy

- Entropy precedes gravity but remains formless

One could almost say that gravity is the source of entropy, but that would be an exaggeration (and inconsistent). There is still entropy before gravity, even if the gravitational state of the Big Bang is not clear to me. In any case, it seems clear that dispersion prevails over gravity, at least before the formation of (hydrogen) atoms. For gravity to produce concentrations of reduced entropy, there must first be primordial entropy to work with, inaugurating the entropic dialectic which is characterized, as with Prigogine's dissipative structures or biological metabolism, by the use of entropic (thermodynamic) energy to create order and sustain counter-entropic processes. Gravity does not create the world out of nothing. It does not precede primitive entropy but gives it form. Without gravity, it would not go very far.

- The primitive world is dominated by processes of dispersion (radiation, expansion).
- Before recombination (the formation of atoms), gravitational forces are dominated by radiation.
- We therefore have "**free" entropy**, which is **not yet structured**: a pure, disorganized flow, primitive radiation, the expansion of space, and heat dissipation.
- But this initial entropy is **pure dispersion**, without structure.

- Gravity gives form to entropy

The universe did not therefore begin with gravity but with **unstructured entropy**. While gravity does not precede this initial entropy, it **makes this disorder operational**, **channels** it, localizes it,

and acts as a **time machine** throughout an erratic evolution producing diverse populations of atoms and planets, until the appearance of other **counter-entropic phenomena** (self-organization, biosphere). Gravity does not abolish entropy—it directs it, tempers it, makes it fertile. There is indeed a primordial entropy, a diffuse background of dissipation and disorder, but this background is not productive in itself. It is only when gravity has left its mark that this entropy becomes form, duration, process.

Since gravity gives form to entropy, it can be considered a **power that structures primitive entropy**, but not as a symmetrical negative entropy that would cancel out entropy, when it is just a **function of diversification, delay, and potential**.

It is not the opposite of entropy, but its **prerequisite** for manifesting itself materially, creating gaps that an entropic world will then **reduce**. Gravity is not simply a conservative force—it is a **power of differentiation**, **of producing complexity** and improbable structures.

By allowing the birth of stars, the fusion of elements, the dissemination of complex molecules, and the emergence of planets, this shaping **constitutes an "entropic capital,"** that is, **a concentrated potential for order** that is usable and subject to entropic wear and tear in a second phase, which is that of a differentiated history. Thus, the local arrow of time arises neither from pure dissipation nor from a fixed initial order, but from the infinite diversity of events in a flamboyant reality that results from the encounter between current local entropic processes and the stardust that is our planetary capital.

- The dialectic of entropy

All this implies that entropy cannot be either what is conserved or what can only increase, as gravity introduces a dialectic between production and destruction. Gravity intervenes not as an origin but as a dialectical operator. It is neither primary nor simply anti-entropic: it is what makes entropy meaningful—no longer simple disorder, but history, differentiation, a reservoir of possibilities where even destruction is creative. It is in this sense that it inaugurates an **entropic dialectic**, moving from diffuse chaos to organized structures that will be sources of potential entropy (through subsequent dissipation) for centers of temporary self-sustaining organization (such as life), which are also subject to cycles of destruction/creation.

This dialectic implies an **unstable coexistence** between **increasing thermodynamic entropy** (disorganizing flux) and **sustainable bubbles of anti-entropy** (structure, complexity, organism), introducing a local, spatial dialectic in addition to the temporal dialectic. In fact, it can be said that if gravity was able to introduce an entropic dialectic by locally decreasing entropy before increasing it abruptly through explosion, it is because entropy itself is dialectical, capable of producing work and sustaining counter-entropic processes. Thus, entropy should no longer be considered as a simple upward curve but as **a fluctuating** (or cyclical) dynamic, as we have seen with stars decreasing entropy before increasing it abruptly in their explosion, which itself provides the fuel for locally decreased entropy. What we call "entropy" is not a straight line but the evolving result of a shifting dialectic between development and catastrophe. It is this contradictory and unpredictable nature that allows entropy to serve as a dialectical structure of reality, rather than a homogeneous determination.

- Entropy is not arithmetic

Unlike energy, entropy is not linear or proportional but qualitative; its dialectical nature also implies a relative character, depending on the point of view and the time frame considered (as Maxwell already knew). What is an increase in entropy for one may be a decrease for another, without what is gained on one side being equal to what is lost on the other. This is typically illustrated by the use of energy (entropic capital) in work (anti-entropic) with destruction on one side but creation on the other, without it being possible to establish any equivalence between energy consumption and the result of the work performed (this is not an energy balance). A small intervention can have major consequences, just as large energy expenditures can prove futile. In fact, apart from purely thermodynamic calculations, entropy calculations are often impossible (what is the result of the increasing complexity of civilization minus the considerable destruction it causes?). Not only is it not mathematically reversible, but entropy **cannot be counted**, as it can collapse instantly. It is more dialectical than arithmetic, combining anti-entropic bubbles (living) with entropic collapses.

- Anti-entropic biological time

The addition of a **fourth form of time**, that of **anti-entropic living**, would opportunely complete this picture, introducing information and finality into the chain of causes, a temporality that is even less mathematical and linear but which is very much present. The temporality of living beings is a teleological temporality, where causes are not only behind (memory) but also ahead (project) — oriented towards an anti-entropic end (reproduction) and subject to the test of hindsight (selection).

We should not rush to say that this biological and teleological time is not physical, because it is well constructed on classical temporality, just as the latter is constructed on quantum temporality. If it cannot be derived from the other three times, it **emerges** in a layer of its own — **biological, historical, existential**. It produces its own temporality (or rather its different temporalities) and inhabits its own living space (which is not only Euclidean), self-sustaining the biosphere and its ecology, which are also physical, material dimensions, just as much as space and time.

As we have seen, living beings are integrated into entropic time: they need energy for their homeostasis and reproduction, they **expend** the entropy capital derived from stars to **achieve local (anti-entropic) goals**. It can be said that in its resistance to entropy, life is a consequence of entropy, and there is no need to insist on the fact that life also shares the dialectical character of entropy in that life feeds on death, just as ecological collapses can be the breeding ground for a higher renewal — after a very long physical period of evolution and reconstruction...