# THE ASYMMETRY OF TIME: A PHILOSOPHER'S REFLECTIONS* **

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The paper confronts two perspectives on the asymmetry of time: a philosophical and a physical one. From the philosophical perspective, time has fundamental asymmetries which together form an asymmetry of time: there seems to exist something like a distinguished Now moving toward the future; we have many traces of the past — both in our memory and in the external world — but no traces of the future; events from the past influence those from the future, but we have no evidence of backward causation; the future seems to be open and we definitely cannot change the past. Because we believe in physics as a fundamental theory describing the world, we expect that physics should explain all of these asymmetries. However, the rub lies in the fact that physics, as it is known at present, is unable to explain these asymmetries. This means that physical processes such as the entropy increase, the expansion of the Universe or those in which weak interactions are involved only form asymmetries in time, that is, they just represent some asymmetrical physical processes in time. The way out of this difficulty can be sought in two directions: either we can look for a fundamental temporally irreversible law of nature which would be able to explain the temporal asymmetries of the world or we should look for the solution of the issue at hand outside of physics, that is, in metaphysics. The paper shows the difficulties of both directions of research.

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## 1. Introduction

I would like to confront two points of view on the asymmetry of time — physical and philosophical — to show that there is some inconsistency between them and explain where the problem lies. I shall also ponder how

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we can try to reconcile them and to show where we can look for a solution. Of course, I am not able to offer a definitive solution, even less one which could be acceptable for both sides of the discourse. But I can at least take comfort from the fact that posing a good question is also worth pursuing.

What is the plan of the paper? First, I shall begin by introducing the problem which I am going to analyze, that is, to explain what the problem of the asymmetry of time consists in and why I maintain that it is still unresolved, or at least not fully resolved. Next, I would like to set out how this problem appears from the physical and philosophical points of view before ending, of course, with some conclusions. What is also interesting, is that it will transpire that the discrimination between philosophy and physics sometimes does not coincide with discrimination between (class of) philosophers and (class of) physicist, that is, we will encounter in the paper a case of a great physicist who is not satisfied with physics and more philosophical than a great philosopher that is an adherent of scientism boundlessly believing in physics.

## 2. The problem

Perhaps it will be the best to begin with Einstein. This is, of course, not an accident: Einstein was deeply interested in the foundation of nature; the foundation of physics; and relations between them (see *e.g.* [1]). He was perfectly aware of the fact that a *new* theory needs a *new* foundation and he looked for it in philosophy (it was, for example, Mach's principle that said that local inertial frames are determined by the large scale distribution of matter, or generally speaking his Kantian approach to science). So, we can say that in his thinking physics met with philosophy.

Coming to the main point of the paper: there is the famous passage from Einstein's letter of condolence to his friend Michele Besso's widow after Besso's death: *People like us, who believe in physics, know that the distinction between past, present and future is only a stubbornly persistent illusion.* Here, we have simple four-dimensional block universe where there is no difference between the past and the future. I would not like to consider the problem of how seriously we should treat this statement by taking into account the circumstances of its writing, but I would rather draw attention to the testimony of Carnap from almost the same time (their conversations took place between years 1952 and 1954 in Princeton while Einstein wrote his letter of condolence in 1955); we know from this report that Einstein was deeply troubled about lacking an explanation for the distinction between the present, the past and the future in physics and rather dissatisfied with the psychological, subjectivist approach to this distinction: *Once Einstein said that the problem of the Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially*

*different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter of painful but inevitable resignation. I remarked that all that occurs objectively can be described in science; on the one hand the temporal sequence of events is described in physics; and, on the other hand, the peculiarities of man's experiences with respect to time, including his different attitude towards past, present, and future, can be described and (in principle) explained in psychology. But Einstein thought that these scientific descriptions cannot possibly satisfy our human needs; that there is something essential about the Now which is just outside the realm of science. We both agreed that this was not a question of a defect for which science could be blamed, as Bergson thought. (. . . ) I definitely had the impression that Einstein's thinking on this point involved a lack of distinction between experience and knowledge. Since science in principle can say all that can be said, there is no unanswerable question left* [2, pp. 37–38].

The citation is long but it is worth recalling: here the attitude of Einstein to the problem of the difference between the present, the past and the future seems a little different than in the letter of condolence — he was upset about it. And there was an interesting disagreement between Carnap and Einstein over the question of differences between the past, the present, and the future; while Carnap thought that science can, in principle, say all that can be said, and if there is no differences between the past, the present, and the future in physics, it should be included into the domain of psychology, Einstein seemed to be not fully satisfied with such a solution. I would like to highlight the problems which could possibly have drawn Einstein's attention and also be the reason for our worries, because they still seem to remain unresolved:

1. The present, which as the only one seems to exist, is still changing or 'moving' toward the future. The past does not seem to exist anymore and the future is to come into being. Additionally, we are convinced that we and other things persist over time by keeping strict identity (philosophers call such a form of existence *endurance*);

2. We have many traces of the past — both in our memory and in the external world — but no traces of the future;

3. Events from the past affected those from the present, but we have no evidence of backward causation (that is, causation is always future directed);

4. The future seems to be open while the past is fixed and we cannot definitely change it.

The second property seems to be a consequence of the third one: past events left traces because they were able to affect the later ones causally (or physically). Nevertheless, the second property is so important feature of our world that I leave it on the list.

All the asymmetries mentioned above concern *fundamental* phenomena of our everyday experience pertaining to time and form something which is called the asymmetry *of* time itself. They should be distinguished from asymmetries *in* time of some physical processes, which do not relate to the fundamental properties of time, such as, for example, when we say *Thank goodness that's over* after an illness, rather than before it. The problem of the direction *of* time has originated from our attempts to understand these fundamental asymmetries and every plausible theory of the direction *of* time should explain them[1].

The essential difference between the past and the future, and the essential role of the present is that the present separates what is fixed and known (by traces) and cannot be changed any more, that is the past, from this which can only be predicted but — at least sometimes — can be affected, that is the future. It means that our understanding of the differences between the past, the future and the present also has to consist of understanding the origin of the asymmetry *of* time.

Now, returning to the debate between Carnap and Einstein: was Carnap right that the differences between the past, the present and the future, and the special part of these differences formed by the aforementioned asymmetries of time are only a matter of psychology or did rather Einstein have a genuine reason to be worried? I claim that Carnap was mistaken and that he did not understand the problem. Let us return to our list of phenomena which asymmetry of time consists of and give Carnap and his adherents as much advantage as it is possible, that is, let us remove from this list any *possible* subjectivist phenomena. So, let us:

1. Treat our conviction that the passage of time is only a consequence of the fact that we have traces of the past and no traces of the future in our memory and that it is a consequence of the third claim concerning the fact that causation is always future directed;

2. Resign from persistence by endurance toward the future and let us assume that it is an illusion and that instead of this we consist of temporal parts (such as things consist of spatial parts);

[1] The first work known to me, in which this distinction was used, was Sklar [3] although it was only introduced there by the conditions (2–4). Sklar stresses in his papers that for a theory of asymmetry of time to be acceptable it should explain the fundamental time asymmetries (2–4).

3. Resign from explanation of the temporal asymmetry of our memory concerning the past and the future (assuming that it could be an illusion);
4. Assume that our conviction about existence of the open future is an illusion despite of indeterministic quantum mechanics.

Now, there still remain — contrary to what was claimed by Carnap — two *objective* asymmetric phenomena which the asymmetry *of* time consists of and which certainly do not belong to the domain of psychology:

1. We have many traces of the past in the external world but no traces of the future;
2. Events from the past affected those from the present, but we have no evidence of backward causation (that is, causation is always future directed).

So, despite giving Carnap some important advantages (resigning from indeterminism and our conviction about retaining our strict identity over time) there remain two important objective aspects of the asymmetry of time which cry out for an explanation. And an important question arises: how we can explain them?

### 3. The asymmetry of time from the physical point of view

Despite some important exceptions, one can say that it is a common view among physicists that there is no flow of time in physics. So, for example, Paul Davies — a physicist deeply interested in the physics of time asymmetry — states with certainty that: *Nothing in known physics corresponds to the passage of time. Indeed, physicists insist that time doesn't flow at all; it merely is* [4, p. 40].

The four-dimensional spacetime block does not appear to leave room for the flow of time. However, if the flow of time does not exist, what is the source of the above-mentioned asymmetries of time?

It seems that we should look for an origin of the asymmetry *of* time within our laws of nature rather than within some *de facto* asymmetries which depend on the initial or boundary conditions of the universe because these last ones would form asymmetries of some physical processes *in* time rather than the asymmetry of time itself. The point is, however, that the electrodynamic, strong and gravitational interactions are invariant under time reversal and as such cannot distinguish any direction of time. In turn, weak interactions are not time reversal invariant, but they are not involved in the processes leading to the coming into existence of the traces of the past which we observe in everyday life (such as, for example, books, historical

monuments or a wet road after rain). They are also not responsible for future oriented causation. And this is why Feynman noticed a long time ago, shortly after the discovery of the CP symmetry violation, that the distinction between the past and the future cannot depend on asymmetries of weak interactions because in normal situations, for example when we are speaking, writing, walking, watching TV *etc.*, weak interactions are not involved[2].

What is more, I would say that time is *maximally asymmetric* because we have *no* traces of the future and we know no cases of backward causation while the weak interactions are only *feebly asymmetric*, that is, for any weak process, a time-reversed sequence of events (the reverse sequence of time reversed states) is possible although it can have a different probability. This is an additional reason for which we cannot appeal to weak interactions to explain the asymmetry of time.

What has remained, and for a long time has been considered as a possible source of the asymmetry of time, was the process of increasing entropy. For example, Ludwig Boltzmann in his well-known *Lectures on Gas Theory* proposed to explain the direction of time just as a direction of rising entropy. He tried to *consider the unique directionality of time given to us by experience as a mere illusion arising from our specially restricted viewpoint* [7, p. 401]. He wrote: *One can think of the world as a mechanical system of an enormously large number of constituents, and of an immensely long period of time, so that the dimensions of that part containing our own 'fixed stars' are minute compared to the extension of the universe; and times that we call eons are likewise minute compared to such a period. Then in the universe, which is in thermal equilibrium throughout and therefore dead, there will occur here and there relatively small regions of the same size as our galaxy (we call them single worlds) which, during the relative short time of eons, fluctuate noticeably from thermal equilibrium, and indeed the state probability in such cases will be equally likely to increase or decrease. For the universe, the two directions of time are indistinguishable, just as in space there is no up or down. However, just as at a particular place on the earth's surface we call 'down' the direction toward the centre of the earth, so will a living being in a particular time interval of such a single world distinguish the direction of time toward the less probable state from the opposite direction (the former toward the past, the latter toward the future). By virtue of this terminology, such small isolated regions of the universe will always find themselves 'initially' in an improbable state. This method seems to me to be the only way in which one can understand the second law — the heat death of each single world — without a unidirectional change of the entire universe from a definite initial state to a final state* [7, pp. 402–403].

[2] Feynman [5, ch. 5]. See also Sklar [3] and Gołosz [6].

Again the citation is long but interesting; Boltzmann compares the directions of time to the directions of space and claims that the direction of time is nothing more than the direction from less to more probable states. Is this explanation plausible? Unfortunately not, because he offers no mechanism responsible for the asymmetry of traces and directionality of causation, there is no explanation of them. And, what is even more important, if the arrow of time was defined (or determined) by entropy increase, the claim that entropy always increases in an isolated system, that is, the second law of thermodynamics, would only be a tautology[3]. I do not suppose that we could desire something like this. Thus it seems that the rise of entropy is only a physical process which is asymmetrical in time.

Perhaps, we can hope that our future more general theory which we are looking for, such as the Theory of Everything (ToE) or Quantum Gravity (QG), will be temporally asymmetrical and will be able to resolve the problem of the asymmetry of time. So Penrose, for example, in his *The Emperor's New Mind* claimed that *our sought-for quantum gravity must be a time-asymmetric theory*[4]. Not all physicists agree with such a postulate but we have an interesting time-asymmetric approach to QG called *Causal Dynamical Triangulation* (CDT), developed by Jan Ambjørn, Jerzy Jurkiewicz, and Renate Loll, in which spacetime has a built-in arrow of time which should allow one to distinguish between causes and effects[5]. If we assume that CDT in some way grounds the fundamental asymmetry of time we experience in everyday life, such a line of attack seems to be very promising because it could make it possible to explain why we have no traces of the future and no cases of backward causation. I would like to notice, however, that although such an approach based on the spacetime with a built-in arrow of time makes it possible to distinguish between causes and effects, it still does not explain what is the origin of the asymmetry (or arrow) of time. It simply takes for granted that it is a primitive property of spacetime which cannot be derived from a more fundamental theory. But, to fully assess such a conception, we have to wait until this theory (CDT) receives its final form.

Now, I would like to turn to a slightly different approach to the problem of the asymmetry of time: a philosophical one.

[3] This was noticed by Eddington [8, p. 93]. See also Earman [9], Sklar [3], and Gołosz [10].

[4] Penrose [11, pp. 344–345, 350–353].

[5] See *e.g.* Ambjørn, Jurkiewicz, Loll [12] and Ambjørn, Görlich, Jurkiewicz, Loll [13]. As I understand this conception, spacetime emerges dynamically from causal time-asymmetric processes.

## 4. The asymmetry of time from the philosophical point of view

Because an approach invoking entropy increase failed, it seems that what remains is to invoke asymmetrical causal relations. So, let us assume that the asymmetry of causation is really responsible for the asymmetry of time, that we have *no* traces of the future and there are *no* cases of backward causation. Then what remains to be considered is to explain what is the source of the asymmetry of causation, whether is it possible to find an origin of this asymmetry based on some time-asymmetrical physical processes which do not appeal implicitly to the asymmetry of time itself. The solution to this conundrum could seem apparently to be simple; causation is time-asymmetrical, effects always occur after causes, so is not this very property responsible for the asymmetry of traces and asymmetry of causation?

This answer is, unfortunately, implausible because, firstly — independently of which definition of causation we adopt, it is reasonable to assume — that in the causal relations which we are interested in, there are always physical interactions involved and these are time reversal invariant (excluding weak interactions, of course). So why cannot the effects of such interactions precede their causes? And secondly — more generally — if just the causation was responsible for the successions of events, why then do we also have many cases of the succession of events which are not causally connected?

Since the time of David Hume, philosophers distinguish between causes and effects with the aim of the asymmetrical relation of temporal priority by calling causes those events that occur *earlier* and effects those which occur *later*. So in such a case, a time asymmetric relation of temporal priority is used to distinguish them in a similar way as it is at present assumed in CDT. Then, however, the essential problem arises as to what is responsible for the asymmetry of this relation? Considerable efforts have been made by philosophers to find an origin — other than temporal, of course — of such an asymmetrical relation of temporal priority in vain simply because physical interactions (modulo weak interactions) are time reversal invariant.

Then, perhaps, we should assume that the relation of temporal priority is simply a *primitive* property of the temporal directionality of our world which does not need further explanations, because some relations and properties of the world have to be primitive?[6] After all — one can argue — we cannot try to explain *all* the properties we find in the world *ad infinitum*.

[6] This is exactly the position taken by Sklar [3, pp. 399, 410–411] because according to him *the causal theory of time is implausible* and *if any reduction thesis has any plausibility at all, it is that which alleges the definability of causal notions by temporal notions and not that which maintains the definability of the temporal by the causal* [3, p. 343].

The assessment of such a proposal depends on what aims we posit: if we simply want to *distinguish causes from their effects*, this procedure is plausible because then the explanation of the asymmetry of time is not our aim. The situation changes fundamentally if we want to *explain the origin of the time asymmetry of the world* because then, assuming the primitive unexplainable property of temporal directionality of our world, it would mean either the resignation of the explanation of a fundamental and bizarre — taking into account that physical interactions are time reversal invariant (excluding the weak interactions, of course) — property of our world, or — if we propose a causal theory of direction of time based on the idea of primitive property of temporal directionality of our world — we fall into a vicious circle in our reasoning: we then claim that time is asymmetrical because it is asymmetrical!

So, what remains is either to wait for a plausible physical theory which will be able to explain the *origin* of the asymmetry of time or to develop a metaphysical conception based on our everyday experience according to which there exists the flow of time, and to claim that it is responsible for the arrow of time. If there is the flow of time, then even if physical interactions which are involved in some events are time reversal invariant, due to the passage of time their consequences can be observed *after* these interactions.

Is it naïve? I would say that not at all; the fact that we have sophisticated thinkers coming from very different directions who should rather not be suspected of being naïve; I will limit myself to Bergson and Eddington. Both develop idea of *becoming*, which is the most promising view on the passage of time[7]: *Matter or mind, reality has appeared to us as a perpetual becoming. It makes itself or it unmakes itself, but it is never something made* [15, p. 296]. *The flux of time is the reality itself, and the things which we study are the things which flow* [15, p. 374].

And Eddington, who wrote in Chapter V, entitled *Becoming*, of *The Nature of Physical World*: *It is absurd to pretend that we have no justifiable conception of 'becoming' in the external world. That dynamic quality — that significance which makes a development from past to future reasonable and a development from future to past farcical — has to do much more than pull the trigger of a nerve. It is so welded into our consciousness that a moving on of time is a condition of consciousness. We have direct insight into 'becoming' which sweeps aside all symbolic knowledge as on an inferior plane. If I grasp the notion of existence because I myself exist, I grasp the notion of becoming because I myself become* [8, p. 97].

[7] See *e.g.* Savitt [14, (2001–2014)] and Gołosz [10].

What is emphasized here by Eddington is that becoming, or the moving on of time — contrary to what was claimed by Carnap — is an objective process which is a necessary condition of our experience.

The notion of becoming can be further elaborated to the form of dynamic existence in order to introduce enduring: things dynamically exist by directional endurance toward the future and thanks to this they keep strict identity over time and — so to say — they can 'carry' traces of past interactions into the future[8].

Such a metaphysical approach introducing the flow of time has some advantages and some disadvantages. The advantages are the following:

1. Because becoming has a directional character, it explains the arrow of time, and especially why we can assume that causes precede their effects despite the time-symmetry of physical interactions (modulo weak interactions, of course).

2. It explains why we observe the world *in statu nascendi*, that is, in the course of being developed, and why we are so interested in empirical sciences in the analysis of the evolution of physical systems (for example, the evolution of the Universe) or evolution of biological systems (in the theory of evolution), and why we are developing ourselves.

3. It explains why we and other things persist over time keeping strict identity (that is, why we and other things endure).

The important disadvantage of such a metaphysical solution to the problem of asymmetry of time is that it introduces a large part of hard metaphysics into the heart of our knowledge about the physical world, that is, it would deserve an essential limitation imposed on the capabilities of physics. In other words, it would mean an acceptance of the fact that physics would be unable to explain a fundamental property of our world — existence of the flow of time. Are we able to accept such a limitation imposed on physics? I am not sure.

Interestingly enough, the above-mentioned approaches — the physical and the philosophical ones — do not have to be inconsistent; they can be complementary as well. If, for example, in *Causal Dynamical Triangulation*, it is assumed that the asymmetry of time is a primitive property of spacetime which cannot be derived from a more fundamental physical theory, a metaphysical origin of the arrow of time can be simply added to this conception in the form of an idea of the flow of time.

[8] See Gołosz [10, 16].

## 5. Conclusions

My main goal of this paper was to draw attention to the deep and still unresolved problem of the asymmetry of time. I have highlighted two possible directions of research which could lead to its solution, a solution which could even turn out to be complementary. Of course, as it often happens, a future development of science can surprise us by a quite unexpected solution to the problem under consideration. What is certain is that the problem is fundamental and cries out for an explanation.

In writing this paper, I have acquired a number of intellectual debts: I should mention in particular Lawrence Sklar, John Earman and Steven Savitt. I would like also to thank Paweł Moskal for the inspiration and Wojciech Wiślicki for his helpful remarks. The errors which remain in the text are, of course, only my own.

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