Why there is no time-symmetry and why initial conditions and laws lead nowhere

Abstract

A very brief argument shows that time reversal is impossible – *in principl*e and not just for statistical reasons.

The same argument proves that initial conditions and laws do not represent a starting point for exact calculations of the evolution of physical systems, not even under idealized conditions.

1. No time reversal

We look at two interacting objects A and B that are moving relative to each other, between two time points T_0 and T_2.

The question is: *Is the time reversal of this real physical process still a real physical process?*

The answer is *no*. The reversed process is not possible in reality, and this applies in *any* case, regardless of which types of objects and interactions are involved and in which environment they are – even if all physical laws that apply to this process are time-symmetrical.

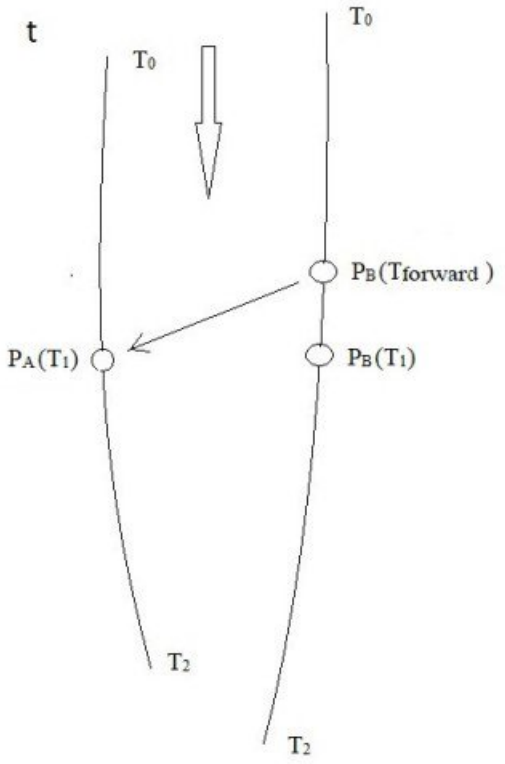
Justification:

Let T_1 be a point in time that lies between T_0 and T_2. A is at position $P_A(T_1)$, B is at position $P_B(T_1)$.

Since the propagation speed of the interaction is finite, the following holds:

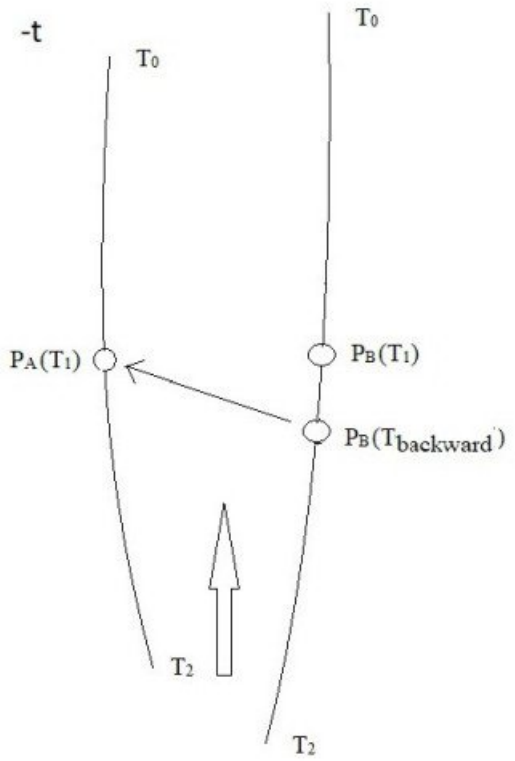
The effect from B, which A is subjected to at time T_1, does *not* originate from B at position $P_B(T_1)$ but from a position where B was *before*, just as long before as it took the effect to get from there to $P_A(T_1)$. We call this position $P_B(T_{forward})$.

(In the sketch, both objects move *downwards*, B faster than A.)



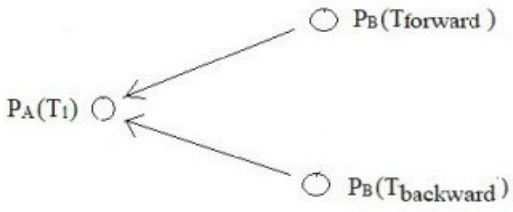
Now we look at the backwards running process. Again we stop it at time T_1. If we consider the process to be real, then again it applies that the effect that B exerts on A at time T_1 does not emanate from B at position $P_B(T_1)$, but from a position where B was *before*. But now B's direction of motion is reversed, and this means that B must be moved along its trajectory *in the opposite direction*, to a position we call $P_B(T_{backward})$.

(In the sketch, both objects move *upwards*, B faster than A.)



In any case, it applies:

$$P_B(T_{forward}) \neq P_B(T_{backward})$$



A necessary condition for a time-symmetrical process is that the acceleration exerted on the objects involved is identical in both time directions at any point in time.

However, since the positions from which the state of motion of the object A is changed by the object B, are *different* for the two time directions, this condition is obviously not fulfilled here.

Thus the backwards running process is no real physical process.

Notes:

1. The definition of the above scenario is so general that it includes every possible physical process: in any process there must be objects that interact with each other so that they change each other's states of motion. It is irrelevant which interactions these are and how they are formulated: in any

case, the objects are *sources* of the effects (carriers of the "charges"), and the effect that an object exerts on other objects *also* depends on the position of the object – and this also applies if no definite position can be assigned to the object but only a probability distribution of positions.

2. Generally, the fact described in the proof can be expressed as follows: If the direction of time is reversed, the positions from which the objects influence each other change, and thus the spatiotemporal causal structure underlying the process must also change.

3. Even if it were not possible to verify the condition "identical acceleration in both time directions at any point in time" in the usual physical representation of the scenario, nonetheless in any case there *is* a representation in which it can be validated.

4. The widespread belief that from the time symmetry of the equations that describe a physical process follows the time symmetry of this process itself is refuted by our argument.

5. An interesting question is to what extent the argument affects the assessment of some scenarios that play an important role in the discussion of time reversal, such as the scenario in which all molecules of a gas are initially in a tiny sub-volume of a closed container and are distributed throughout the whole container after a while. I suspect that in this case, too, the deviations (angle changes of the trajectories) that follow from our argument – even if they are extremely small – escalate after a relatively short period of time to such an extent that they abolish the time-reversibility of the process: the molecules will not gather again in the tiny sub-volume – not even if the conditions at the end of the process serve *exactly* as starting conditions of the time-reversed process. (That's just a guess, though; I didn't calculate how long one would actually have to let the process run to prevent this outcome.)

6. According to thermodynamic arguments, time reversal is improbable. Our argument proves that it is impossible.

7. Let us assume that a physical system approaches an attractor state, i.e. a state of lower entropy. If time reversal existed, then the reverse trajectory would also be possible. But since we have ruled out time reversal, this trajectory cannot exist – the time-reversed path back to higher entropy is not possible.

2. Further inference

Accurate knowledge of initial conditions and laws is generally considered a safe starting point for calculating the evolution of physical systems. Only limitations of measuring and calculating then prevent exact results.

However, our argument shows that there is a fundamental (absolute) limitation: even a Laplacian demon with infinite resources of space, time and information would not be able to carry out an exact calculation on the basis of initial conditions and laws, because he would not even be able to *start* with it: In order to determine the effects to which any of the objects of the system is initially subjected, all other objects would have to be put back to the positions from which these effects emanate, and obviously this cannot be done exactly, because the same applies to all objects.

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