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 principle and not just for statistical reasons. The argument applies to all systems that contain (also) macroscopic objects, i.e. objects for which the quantum-mechanical uncertainty of position can be neglected. 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.

The justification is so simple and evident that it is sufficient in itself. References and quotations are therefore superfluous.

1. No time reversal

We film two interacting macroscopic objects A and B, which are moving relative to each other, between two time points T_0 and T_2. Afterwards we play the movie in reverse direction.

The question is: *Does the backwards running film show a real physical process?*

The answer is *no*. The process that the backwards running film shows 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:

We stop the forward moving film at time T_1, which 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 $P_B(T_{\text{forward}})$.

Now we play the film backwards. Again we stop it at time T_1. If we consider the process shown 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 $P_B(T_{\text{backward}})$.

In any case it applies:

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

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 A and B is changed by the other object, are different for both time directions, this condition is obviously not fulfilled here.

So the backwards running film shows no real possible 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.

2. Even if it is 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, because the points in time change due to the time reversal, nonetheless there exists a representation in which it can be validated: e.g. our "movie" is such a representation, and since it is a thought experiment it can even be assumed to be exact. (However, the propagation times of the light from the objects to the camera must be observed.)

3. 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.

4. 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.)

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

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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