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BECAUSE OF SPACE-TIME SYMMETRIES, ACCEPTABLE MICRO-ACAUSALITY INEVITABLY LEADS TO THE POSSIBILITY OF MACRO-SCALE CAUSALITY VIOLATIONS

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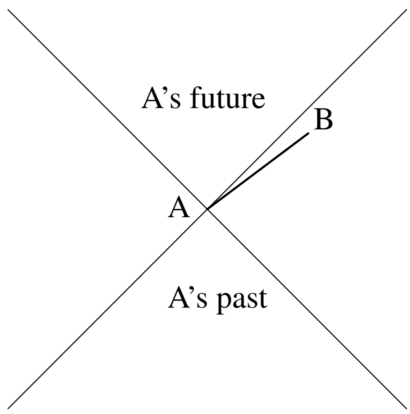
Аннотация. In this paper, we show that because of natural space-time symmetries, acceptable micro-violations of causality inevitably lead to the possibility of macro-scale causality violations. We also discuss how such macro-scale violations can be potentially detected.

Ключевые слова: Causality violations, space-time geometry, symmetries..

1. Micro-causality violations are acceptable in quantum physics

General idea. According to quantum physics (see, e.g., [2–4]), the actual values of all the fields include random fluctuations. In particular, this is true for the actual values of the metric tensor g_{ij} that described space-time – and its causality. This means, in particular, that even in flat Minkowsky space-time, due to quantum effects, the actual speed of light – as determined by the local values of the metric tensor field – fluctuates around the classical value c. This means that in some locations and in some directions, the speed of light is slightly larger than c – i.e., that we have causal effects outside the usual future cone:



Comment. Of course, in the above picture, the deviation from the non-quantum causality is grossly exaggerated: the actual quantum-based fluctuations of the metric tensor in the

Minkowski space are very small, several orders of magnitude below what we can currently detect.

Additional confirmation. In the previous text, we explained general reasons why quantum physics can lead to micro-casuality violations – i.e., to micro-effects that seemingly violate the usual causality. Detailed analysis of quantum field theory – see, e.g., [1] – confirms this general conclusion. Namely, this analysis shows that on the microscopic level, the quantum Green function – that describes the effect of a single space-time event – spreads beyond the usual future cone: a little bit beyond, but still beyond.

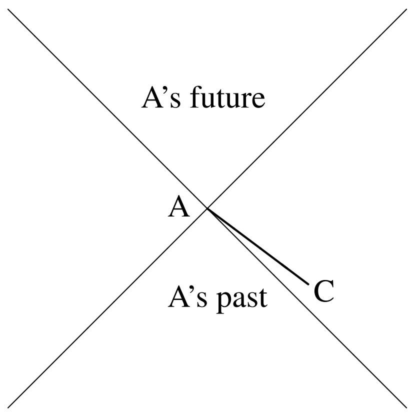
2. Because of symmetries, this leads to the possibility of macro-scale causality violations

Symmetries: reminder. Minkowski space-time of Special Relativity has many symmetries:

- spatial and temporal shifts,
- spatial rotations,
- scalings (homotheties) $t \mapsto \lambda \cdot t$ and $x_i \mapsto \lambda \cdot x_i$, and
- last but not the least, Lorentz transformations – that describe a transition to a moving frame of reference.

Specific feature of these symmetries. It is known that for each space-time point A, and for every two points B and C which are not in the future or past of A, there is a symmetry that keeps A intact and turns B into C. In particular, by using only Lorentz transformations, we can:

- transform the above-described space-time point B – that is close to the future cone
- into a point C that is close to the past cone; see below.

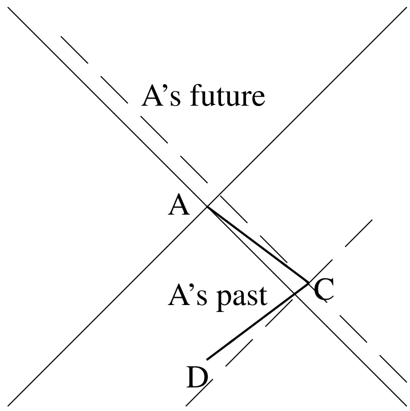


This transformation corresponds to using a new frame of reference, a frame that is moving with speed close to the speed of light c in relation to the original frame.

How this can lead to a macro-scale casuality violation. In the last picture, we are close to the past cone, but we are still outside the past cone, i.e., we do not (yet) have a causality violation. However, if we combine two such effects:

- the effect of A on C and
- a similar effect of C on a new space-time point D,

then we get an effect of the space-time point A on the space-time point D, which is located in A's past:



Specifics. To get from A to C, we need to use a coordinate frame that moves, with respect to the original one, with a speed close to the speed of light. To get from C to D, we need to use yet another frame that also moved with a speed close to c with respect to the original frame – but that moves in the opposite direction.

So, to affect the past from our state, we need to have two auxiliary systems that move with a speed close to the of light in two opposite directions.

- We then engage a micro-causal violation in the first moving system – which enables us to, e.g., send a signal from our space-time point A to an auxiliary space-time point C.
- After that, we engage a micro-causal violation in the second moving system – which enables us to forward the signal form the auxiliary space-time point C to the desired space-time point D which is located direction in our past.

3. How can we detect such processes

The above possibility is theoretically possible, but it is way beyond our abilities. The above scheme requires that we move complex devices with a speed very close to the speed of light. There are no fundamental physical reasons why we cannot do that, but at present, our technology is not yet capable of this. The closest we can do is accelerate, in a particle accelerator, a small set of protons or alpha-particles to speeds close to the speed of light – but this is very far from similarly accelerating the whole quantum device that would enable us to observe and utilize micro-violations of causality.

While we cannot (yet) implement this scheme, we can try to detect if anyone uses such schemes. The fact that we cannot yet implement such a scheme does not mean that the above analysis is completely useless: while we cannot *implement* this scheme, we can try to *detect* whether anyone in the Universe uses such schemes.

To implement such a scheme, it is necessary to have two systems moving in opposite directions with speed close to speed of light. This will enable us to perform a *one-time* communication with the past. To maintain *continuous* communication with the past, we need steady flows going with speeds close to c in opposite directions. Interestingly, in our Universe, there are many astronomical objects with such hyper-relativistic flows. So maybe some advance civilization out there uses these natural phenomena to communicate with the past? And maybe some of such objects have been artificially designed by these civilizations with the explicit purpose of communicating with the past?

Based only on the close-to-c speeds, it is difficult to decide whether such objects naturally appeared this way and if yes, whether they are utilized for communicating with the past. But what we do is pay special attention to these objects – e.g., try to decode the radio signals coming from these objects, or look for other features that would indicate that this is a not a completely naturally appearing phenomenon.

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