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Is it possible to travel in Time?

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1. Introduction

It is told and written very much on the travelling in Time and time machines. I would like talk about two things only that were not discussed enough so far:

- The *material body* displacement backward in Time is *technically impossible* because of instant annihilation of the body.

- In the Relativity one uses the object *proper* time concept. However, there is the preferred (*comoving*) reference frame in which the observer's time is always coinciding with the whole Universe *age*. Any displacements forward or backward in Time relative this comoving time are *impossible*.

Correspondently, the talk's plan is as follows:

- It is impossible to displace a material body backward in Time
- Closed Timelike Curves
- The proper time dilation and contraction in the Relativity
- About the concepts of Time and time machine
- About the travelling through the wormholes

2. A material body cannot be displaced backward in Time

The fist statement (which I propose to name "the Wheeler argument") can be explained very simply. In 1964 in his Nobelian Prize's lecture Richard Feynman talked that his scientific adviser Jhon Wheeler called and informed him that an electron and positron's meeting (followed by the mutual annihilation) might be interpreted as the electron wordline returning backward into the past: the proper time sign *change* is equivalent to the charge sign change (the CPT-symmetry theorem). Feynman accepted this idea: one could think about positron simply as electron travelling from the Future into the Past (Fig. 1).

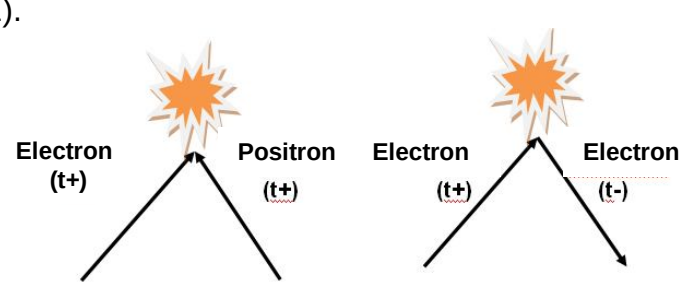


Figure 1a

But this means that any time machine started *backward into Time* which consists of electrons and protons (including all it contains) will directly become the object consisting of positrons and anti-protons!

Let us now imagine that such the time machine is created, a passenger (or a special equipment) is inside of it, and the machine started into the Past from time point T1 up to T2. From the viewpoint of the "usual" Time course (where T1 > T2) one can say that the macroscopic fully *anti-material* exemplar of the machine exists since the time point T2 up to T1 when the source machine will only appear and annihilate with the anti-machine. However, the probability close to 1 exists that such the anti-machine will annihilate much before with its environment.

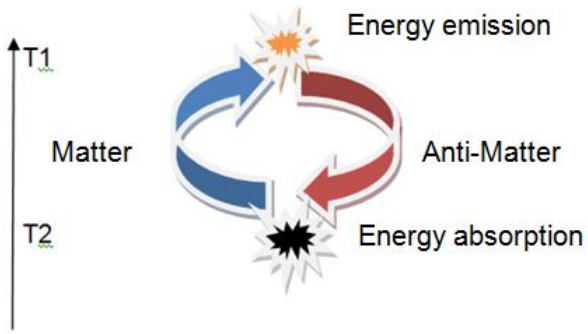


Figure 1b

3. Closed Timelike Curves

If it is technically impossible to displace backward in Time a body consisting of the atoms, then a problem is eliminated that was actually discussed so far.

Let us remember the famous movie "Back to the Future"[1] and many other movies, books and mythes, in which the characters freely displace backward and forward in Time. At this their worldlines intersect and form "Closed Timelike Curves (CTC)".

J. Whheler and R. Feynman initiated the discussion on the time loops paradox in the paper **[Wheeler J.A., Feynman R.P. Classical Electrodynamics in Terms of Direct Interparticle Action, Reviews of Modern Physics, vol. 21, numb. 3, p. 425-433 (1949)]**. Since this publication many works were dedicated to such the phenomena. The commonly accepted viewpoint states that such loops existence could lead to the paradoxes that are not observed really. The existence of the Closed Timelike Curves (CTC) in RG was proposed to discuss by Kurt Friedrich Godel in 1949 r. (Godel's metrics). Much has been written on two possible remedies to the paradoxes, namely the Principle of Self-Consistency and the Chronology Protection Conjecture. The first one stipulates that events on a CTC are self-consistent, i.e., events influence one another along the curve in a cyclic and self-consistent way. Hawking's Chronology Protection Conjecture is a more conservative way of dealing with the paradoxes. Hawking notes the strong experimental evidence in favour of the conjecture from the fact that we have not been invaded by hordes of tourists from the future.

The simplest example of CTC is represented by so-called "grandfather's paradox". Somehow travels into the Past and kills his grandfather. As result, he eliminates the possibility of his birth and such the travel at all. This paradox cannot be solved excludind the exotic idea of the multiverse.

In fact, such the paradoxical situations do not appear, not only with a material particle which travelled backward in Time and annihilate. A photon is the own anti-particle, however, it seems, the Nature iterdicts to it the travelling in Time. The

[1] As it is clear from below, the people around the main characters should observe theirs copies consisting of anti-matter!

experiments were performed in the Massachusetts Institute of Technology (MIT) where a *future issue* influenced the *past photon's polarization* (such paradoxical fact does not contradict to the quantum theory). However, *actually* the photon teleportation into the Past happened only if the source experiment configuration turned out to be *compatible* with the future issue ("the grandfather was not killed" due to some accidental circumstances). Contrary, if the compatibility was absent ("the grandfather just was killed"), then teleportation was destroyed (with an expected probability). So, some natural mechanism exists that prevents such the paradox appearance **[Justin Mullins. Time machine or grandfather's paradox. New Scientist. March of 2011]**.

4. The proper time dilation and contraction in the Special Relativity

Let us leave practical difficulties of travel in Time and consider the theory. What the Relativity (the base of the modern theoretical physics) tells us?

If we attempt to synchronize the GPS-receiver clock and a satellite clock, we need take into account the velocity effect onto the Time course. Accordingly the Special Relativity the *proper time* of a quickly moving body dilates relative to the immobile reference frame. Each GPS satellite flies at the orbit with the speed near 14,000 km/s, so atomic clock on it is about 7 microseconds per day slower than the terrestrial clock. On usually describes this effect as "twins paradox" (Fig. 2): when the first twin stays on the Earth while the other one travels in Space with great velocity, after their new meeting on the Earth the traveler turns out to be younger than his brother; the space traveler *proper* time is

$$\Delta t_{Traveller} = \Delta t_{Earthman} \sqrt{1 - \frac{v^2}{c^2}},$$

where v is the rocket velocity, c is velocity of light.

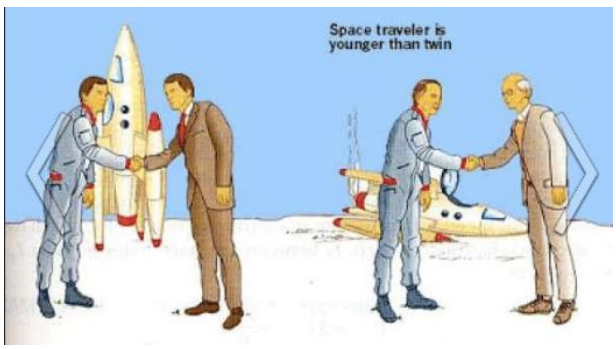


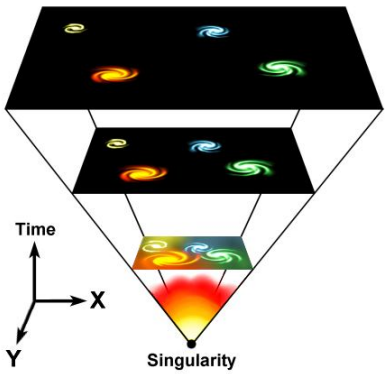
Figure 2. Twins paradox
[from http://startswithabang.com/wp-content/uploads/2009/02/twin-paradox.jpg]

The gravity influences the Time course more strongly. The average radius of an Earth's satellite is near 26,000 km; the attraction force is about four times less there than this one on the planet's surface. Because of that the satellite's clock is 45 microseconds per day *faster* than the terrestrial clock. As result, we need in the GPS time correction equal to 45 – 7 = 38 microseconds. Without such the correction the distance determination error will increase by 11 km per day.

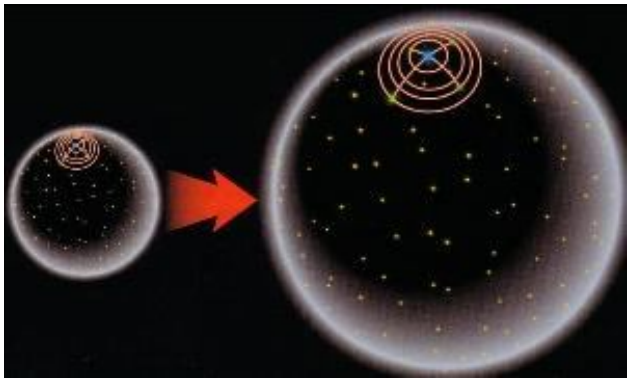
So, the Relativity tells us that it is generally possible to slow or fast the *proper* time. However, one cannot displace a rocket into the Past (to the moment point preceding the start moment point) using similar scenario.

4. Time and time machine concepts

Note, the Relativity allows us consider the observer proper time course using the clock rigidly associated with its *particular* reference frame. So, does some *universal* Time exist?



The Universe open model
[Picture from
http://commons.wikimedia.org/wiki/File:Universe_expansion_(fr).PNG]



The Universe closed model
[Picture from
http://galspace.spb.ru/index60.file/ras.jpg]

Figure 3

It is turned out, yes! Though the Relativity allows to formulate the physical laws using an *arbitrary* reference frame, one commonly uses in cosmology so-called *comoving* one. It assigns the fixed values of the spatial coordinates for observers that perceive the Universe as *isotropic* one. Such the observers move together with the Hubble flow. The comoving observer is the single one at the *fixed spatial point* for which the Universe (including CMBR) is isotropic. Any other observer will see the different sky areas as having the regular blue or red shift. So, the isotropy (particularly, relative to CMBR) defines in *each spatial point* of the Universe the special local reference frame that is called as comoving one.

The Universe expansion in the *open* and *closed* models is illustrated in the Fig. 3. It is possible to use the coordinate system where all the distances are expressed through the same (at the different spatial points) scale factor that increases with Time.

Each the Universe evolution time moment (a fixed horizontal parallel in the Fig.4, http://commons.wikimedia.org/wiki/File:Universe_Expansion_Timeline_(fr).png) corresponds to a concrete scale factor value; these parallels are similar to annual rings of a tree.

Such the parametrization aloows to tell about some kind of the time “layers”. Every layer is the common cosmological Time for all Universe (measured along the vertical meridians, see Fig 4) and does not coincide with a local proper time intervals used in the Relativity.

Now we can try to answer the question: What means “the time machine”? We will explain this using Fig. 5. From the “naive” point of view we could think that a displacement in the comoving time is not connected at all with a spatial displacement. However, it is impossible in principle: The Universe at each time point of its evolution exists in the single exemplar only; any Universe exemplar at other cross-sections of Fig. 4 is a fiction, our fantasy only. Similarly, a train that goes on railway is really existing only in a single place (Fig. 6), so its past and future positions (e.g., at the beginning and at the end of the way) are an abstract image only.

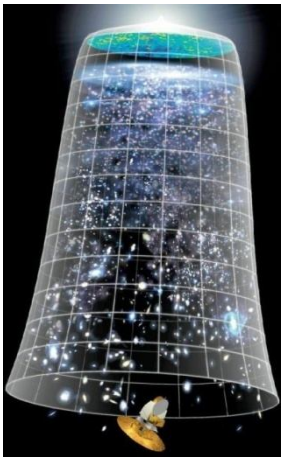


Figure 4

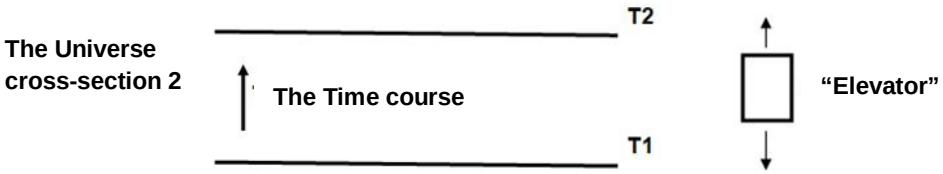


Figure 5

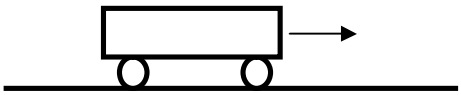


Figure 6

5. On the travelling through wormholes

In the last decades one much discusses about wormholes. One states that they can assure a bypass of the largest spacetime regions (Fig.7). In my opinion, such the statements aren’t correct.

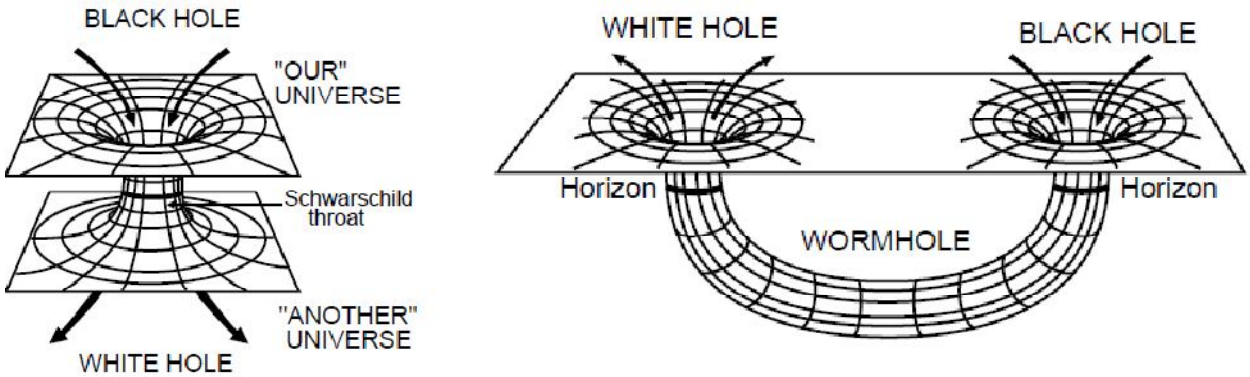


Figure 7

J.-P. Luminet. Black Holes: A General Introduction.
[http://arxiv.org/pdf/astro-ph/9801252.pdf]

First, there is no any evidence that such the object exist. Even theoretically the picture is much more complicate than Figure 7 shows. In fact, the conformal Kruskal transformation is used there instead of the natural coordinate system representation. This transformation maps infinite spacetime regions onto finite areas, it is very

comfortable to look at them, but it is the mathematical trick only. Nobody knows how to move and navigate in such the world. Further, let me quote now the famous physicist:

> Einstein and Rosen speculated that the interior of a black hole might connect to a very distant place, through what Wheeler would later call a *wormhole*. The idea was that two black holes, perhaps billions of light-years apart, could be joined at their horizons, forming a fantastic shortcut across the universe. …
>
> That's the origin of the urban myth that the black holes are tunnels to other worlds. But there are two things wrong with this fantasy. The first is that Wheeler's wormhole can stay open for only a short period of time, and then it pinches off. The wormhole opens and closes so quickly that it is impossible for anything to pass through, including light. … Some physicists have speculated that Quantum Mechanics might somehow stabilize the wormhole, but there is no evidence for this.
>
> Even more to the point, Einstein and Rosen were studying an "eternal black hole" – one that exists not only in the infinite future but also into the infinite past. But even the universe is not infinitely old. … When Einstein's equation are applied to the formation of black holes, the blacks holes simply do not have wormholes attached to them.
>
> **[L. Susskind. The back hole war. My battle with Stephen Hawking to make the world safe for quantum mechanics. Back Bay Books, Little,Brown and Company, New York – Boston – London, 2008]**.