A philosophical argument against time machines

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Abstract

Closed timelike curves, or time machines, are objects within General Relativity. Such objects bring a myriad of unsolved paradoxes. Convincing and general arguments against time machines and their paradoxes are missing today in physics and philosophy. In this article, a philosophical argument against time machines is given. According to the presented argument, the unconscious belief in the principle of individuation motivates the belief in time machines. Then, assuming a process of individuation instead of a principle of individuation, one denies any type of human travel into the past.

Keywords: Time Machines, Closed Timelike Curves, Process of Individuation, Becoming

1 Introduction

Time machines are among the most interesting and attractive subjects (especially for the general public) in theoretical physics. The existence, at least mathematically, of spacetime curves, or paths, where an observer would travel into the past or into the future is indicated by General Relativity. Such curves are called closed timelike curves (CTCs) and appear in some solutions of Einstein’s field equations. The question in General Relativity is not merely the time flux and its “pace” as described in Special Relativity. In General Relativity the possibility of returning into the past brings paradoxes like the problem, for an observer, of traveling into the past to kill, for example, his own grandfather. There exist some physical and philosophical arguments that try to avoid such paradoxes. Hawking (1992) with his Chronology Protection Conjecture, for example, tries to avoid the paradoxes and causality violations which involve time machines. Hawking uses, among his arguments to reject CTCs, the confirmation according to which if time machines were possible, we would see “hordes of tourists from the future”[1] Moreover, Hawking shows physical results, which come from Quantum Theory and General Relativity, to reject time machines. In his physical argument,
Hawking concludes that backreaction effects due to a large expectation value of the energy-momentum tensor would avoid the formation of CTCs in a spacetime.

In General Relativity, the very first solution with CTCs was the van Stockum (1937) solution. But the existence of such curves in van Stockum’s metric was only indicated by Tipler (1974) years later. The impressive Gödel (1949) universe—a cosmological model with rotation developed during the forties—has CTCs as well. There are other metrics in General Relativity with curves to travel in time, such as the two non-intersecting cosmic strings of Gott (1991). The Einsteinian theory of gravity provides naturally such curves, and a strong, definitive and general argument to exclude CTCs and its paradoxes within General Relativity or theories beyond is missing today in physics.

In this paper, I present a philosophical argument to deny the reality of CTCs, or time machines. According to the presented argument, time machines are forbidden because individuation is an uninterrupted process. That is, it is shown that individuation—when it is not considered a process—leads to the beliefs in isolated entities and, consequently, time machines. Such isolated entities, or individuals, are fictional, even more whether one considers humans as such entities. Because humans are generated by processes of individuation, are immersed in collective contexts. Moreover, I consider individuation a processes by assuming totally the notion of becoming, such as Friedrich Nietzsche and Heraclitus of Ephesus.

It is worth to emphasize that the argumentation in this article is philosophical. To deny time machines (focusing on travels into the past), I shall not use physical and mathematical concepts like Cauchy surfaces, geodesics, backreaction effects, singularities and others. I shall emphasize the concept of individuation instead of physical-mathematical concepts as indicated, for example, in Earman et al. (2009).

The structure of this article is as follows: in Sec. 2 a very brief review on CTCs in Einsteinian theory is given to illustrate the concept of CTCs; Sec. 3 presents the definition of both the principle of individuation and the process of individuation, and I discuss a solution for time machines by using the philosophy of becoming. The final remarks are presented in Sec. 4.

## 2 Closed timelike curves or time machines

General Relativity is the theory of space, time and the gravitational phenomenon, generated by both matter and energy. The most important Albert Einstein’s work has been tested and approved until today. The most recent test was the gravitational waves detected by LIGO Collaboration (Abbott et al., 2016). During the 20th century, General Relativity obtained successful results and reliability. But should all results in General Relativity be considered reliable? Among their predictions (black holes, gravitational waves and the initial singularity or the supposed big bang), closed curves, in particular timelike curves which are periodic, are within Einsteinian theory. Timelike curves are the natural path of observers. Periodic timelike curves are paths where, according to Einsteinian theory, observers would travel into

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2A review on CTCs in General Relativity is found in Lobo (2010). Earman et al. (2009) discuss some time machine paradoxes and questions on the possibility of generating CTCs according to the laws of physics.

3Supposed because bouncing cosmologies—models without a big bang—are possible in science today (Novello and Perez Bergliaffa 2008; Neves 2017).
the past or the future. The question in General Relativity is geometric. Different spacetimes (or geometries) may provide such special curves and—at least mathematically—a direct form to travel in time. Then, among the researches in General Relativity, CTCs mean time machines.

Typically, but not generally, CTCs appear in geometries with axial symmetry. A general stationary metric with axial symmetry which presents CTCs is given in the \((t, r, \phi, z)\) coordinates by

\[
ds^2 = -F(r) dt^2 + H(r) dr^2 + L(r) d\phi^2 + 2M(r) d\phi dt + H(r) dz^2,
\]

where \(t, r\) and \(\phi\) are the temporal, radial and angular coordinates, respectively, and \(z\) indicates the distance from the rotation axis. Moreover, the metric functions \(F(r), H(r), L(r)\) and \(M(r)\) do not depend on the temporal coordinate \(t\) as every stationary metric. CTCs appear when the metric term \(g_{\phi\phi}\) becomes timelike, which in the metric signature presented in Eq. (1) is translated by a negative value for \(g_{\phi\phi}\). That is, one has CTCs when the condition \(L(r) < 0\) is satisfied. If the function \(F(r)\) is positive and \(L(r) < 0\), the metric (1) will present two timelike coordinates, \(t\) and \(\phi\). As we know, the coordinate \(\phi\) is the azimuthal coordinate and it is periodic by construction, i.e., \(\phi\) assumes the values between 0 and \(2\pi\). Then when \(L(r) < 0\), in a specific curve \(\gamma = (t_0, r_0, \phi, z_0)\), the coordinate \(\phi\) promotes a periodic timelike curve. Such a curve may be closed, in this case it is called closed timelike curve. By means of the identification between \(\phi = 0\) and \(\phi = 2\pi\), it is ensured the return to the past. That is,

\[
(t_0, r_0, 0, z_0) = (t_0, r_0, 2\pi, z_0),
\]

and a traveler through \(\gamma\) would return from the time \(\phi = 0\) to \(\phi = 2\pi\) in this hypothetical time machine. Thus, as we can see, apart from some criticisms on the indicated identification, mathematically some metrics with axial symmetry are able to generate CTCs within Einsteinian theory. Among them, the \textbf{van Stockum (1937)} metric is described as an infinite cylinder in rotation (made of dust) immersed in a vacuum spacetime. Specifically, the metric terms in Eq. (1) assume the forms \(F(r) = 1, H(r) = e^{-\omega^2 r^2}, L(r) = r^2(1 - \omega^2 r^2)\) and \(M(r) = \omega r^2\) for the interior of van Stockum’s solution, with \(\omega\) playing the role of the cylinder angular velocity. Therefore, for van Stockum’s geometry, CTCs are possible in the cylinder interior with \(1 - \omega^2 r^2 < 0\) or \(\omega r > 1\). Following \textbf{Lobo (2010)}, assuming that the cylinder radius is \(r = R\), even the exterior solution is able to generate CTCs when \(\omega R > 1/2\), i.e., a rapidly rotating cylinder would provide CTCs in the entire van Stockum’s spacetime.

But spherically symmetric metrics are able to generate CTCs as well. The wormhole of \textbf{Morris and Thorne (1988)}—endowed with spherical symmetry—may be a shortcut, or tunnel, in the spacetime between two remote distances. Moreover, by means of the energy conditions violations, wormholes are able—at least theoretically—to create time machines \textbf{(Morris et al., 1988)}.

Physical arguments against CTCs have been pointed out as well. In Introduction, we saw Hawking’s argument. But, even in physics, there are others. In \textbf{Deser et al. (1992)}, it is shown that Gott’s time machine has unphysical origin or source. In \textbf{Pavan et al. (2010)}, on the other hand, CTCs are denied from the perturbative method. The authors show that cylindrical spacetimes with CTCs are unstable against scalar perturbations. However,

\[\text{See, for example, Cooperstock and Tieu (2005).}\]
these studies are not general, they were made from both a specific background, or class of metrics, and a particular field, the scalar one in Pavan et al. (2010). Even Hawking’s criticism depends on either the unacceptance of the weak energy condition violation or the validity of large backreaction effects, which would prevent the CTCs formation. But today in physics, violations in energy conditions are more acceptable since the detection of cosmic acceleration, promoted by dark energy, and the backreaction effects are speculations from a quantum theory of gravity not complete yet. Thus, a general and convincing physical argument against CTCs is missing today in physics. Nevertheless, I suggest a philosophical argument against CTCs in the next section.

3 The problem of individuation

In this paper, I construct the argumentation against time machines by using the philosophical concept of individuation, or generation of an individual. For various thinkers in the history of philosophy, individuation has an origin: a supposed principle of individuation (principium individuationis). The principle of individuation was a very useful concept adopted by philosophers. The Cambridge dictionary of philosophy, for example, says that the principle of individuation is “what makes something individual as opposed to universal”\(^5\). In this sense, a specific man is different from the universal man because of the principle of individuation. Then, according to this perspective, our world is “made up” of various entities, or individuals, because the principle of individuation is present.

In Arthur Schopenhauer’s philosophy, the principle of individuation promotes the world as representation. As being-in-itself (or thing-in-itself) is Will, something beyond the principle of individuation,\(^6\) Schopenhauer claims that such a principle generates individuals from Will, or unity, which is the origin of the world, “the innermost essence, the kernel, of every particular thing and also of the whole”\(^7\). Therefore, unity, or thing-in-itself, presents itself as a myriad of objects, i.e., our physical world is Will by means of the principle of individuation.

In the same direction, for the young Friedrich Nietzsche, the principle of individuation is identified to a drive (Trieb), which receives the name of the Greek God Apollo. But the origin of the world, such as in Schopenhauer’s work, is attributed to unity, which in Nietzsche’s initial philosophy is the Primordial Unity (Ur-Eine)\(^8\). Above all, the metaphysical principle of individuation was the attempt of describing the multiplicity in terms of a unique origin, or a unique cause, for those important thinkers. Thus, individuation and its supposed cause, the principle of individuation, are ingredients to justify the physical world from a metaphysical origin.

Without metaphysical speculations, individuation may be seen as natural process. Instead of a metaphysical principle, individuation may be considered process, described by

\(^5\)Audi (1999, p. 737).

\(^6\)In Schopenhauer, the principle of individuation is equivalent to space and time: “I shall call time and space the principium individuationis, an expression borrowed from the old scholasticism (...).” Schopenhauer (1969, Second Book, 23).

\(^7\)Ibidem, 21.

\(^8\)Nietzsche (2007, I). The mature Nietzsche rejected Schopenhauer’s influence, and from the maturity period, he created his concepts, like will to power. Even the Primordial Unity was ruled out, because the world as wills to power is plural. Cf. Müller-Lauter (1993).
physical concepts. Thus, to think about individuation means to realize a process with degrees. Then, the individual is not generated instantaneously. The French philosopher Gilbert Simondon (Simondon, 1992, 2009) interpreted individuation as process of various degrees. For Simondon, the individual is the process of individuation acting. The individual, in his perspective, is a metastable system which comes from another metastable system: the preindividual. Both living beings and physical objects are systems with non-vanishing potential energy, are processes, i.e., are not static beings.

The process of individuation must be considered primordial, for it is this process that at once brings the individual into being and determines all the distinguishing characteristics of its development, organization and modalities. Thus, the individual is to be understood as having a relative reality, occupying only a certain phase of the whole being in question – a phase that therefore carries the implication of a preceding preindividual state, and that, even after individuation, does not exist in isolation, since individuation does not exhaust in the single act of its appearance all the potentials embedded in the preindividual state. Individuation, moreover, not only brings the individual to light but also the individual-milieu dyad.

For Simondon, the process of individuation, or individuation, does not generate an isolated being. The individual-milieu dyad also appears during the process. In Simondon, we find a description of the problem of individuation as uninterrupted process. Individuals are not static beings, something firm, without any relation with the environment (milieu). In Simondon’s philosophy of individuation, a full, complete and isolated individual is something fictitious. For an individual, a living being, the process of individuation acts continuously, individuating itself: “The living being resolves its problems not only by adapting itself which is to say, by modifying its relationship to its milieu (something a machine is equally able to do) – but by modifying itself through the invention of new internal structures (...)”.

Following Simondon, for example, Weinbaum and Veitas (2017) proposed a new form to define and conceive intelligence by means of the process of individuation. For those authors, intelligent agents emerge from a complex context and become intelligent from a process of self-organization and formation, where “individuation is a resolution of a problematic situation”.

In my opinion, Simondon’s process of individuation brings concepts and similar interpretations to Heraclitus and Nietzsche. As for Heraclitus, one can see the importance of becoming, or process. Such as in Nietzsche’s philosophy, one can find the question on the “stability” of individuals. In the mature Nietzschean philosophy, individuals are transitory configurations of wills to power.

In this article, the main argument to deny time machines is found in an image from Heraclitus of Ephesus. And images, or metaphors, have been useful in science as well. In

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9. I intend therefore to study the forms, modes and degrees of individuation in order to situate accurately the individual in the wider being (...), see Simondon (1992, p. 311).
10. Simondon (1992, p. 300).
11. Idem, p. 305.
12. Weinbaum and Veitas (2017, p. 10).
13. At least the Platonic Heraclitus, cf. Kahn (1979). Denying any eternal substance, Simondon says that “the opposition between being and becoming can only be valid within a certain doctrine that supposes that the very model of being is a substance”. Cf. Simondon (2009, p. 6).
14. Cf. Müller-Lauter (1993).
Thermodynamics, for example, the volume of a perfect gas may be thought of as a set of noninteracting little balls. In General Relativity, the spacetime curvature may be suggested by a heavy body upon a trampoline, deforming its surface. In particular, a metaphor is used to promote hypothetical time travels: it is the time traveler metaphor as a “free particle”. As we shall see, an isolated individual, generated by a hypothetical principle of individuation, or equivalently a complete process of individuation, is the origin of such a metaphor. Then, as we can see, the metaphorical ingredient is present to think about (or to construct) the reality in the most abstract natural science as well.

Heraclitus, “the philosopher of becoming”, is supposed to say, according to Plato, “that all things are in motion and nothing at rest (…)”. The philosopher of Ephesus compared all things “to the stream of a river” and said “that you cannot go into the same water twice”.

Not only the river flows, but everything is in flux, even the observer who observes the flux: “In the same river, we both step and do not step, we are and we are not”. Thus Heraclitus denied the stability of the entire world. For Nietzsche, above all, Heraclitus denied the concept of being as something static, considering it illusory and fictional. The German philosopher and philologist, Nietzsche, was a hard critic of the philosophical language. Behind philosophical concepts, Nietzsche saw prejudgments and idiosyncrasies. Nietzsche, in the mature period of his work, criticized philosophy and its dogmas, the philosophers and their bias and prejudices. By means of a strong language criticism, the German philosopher attacked the foundations of philosophy and science. And the notions of both thing and thing-in-itself are within his criticism. In a fragment, Nietzsche wrote:

The “thing-in-itself” absurd. If I think away all the relationships, all the “qualities”, all the “activities” of a thing, then the thing does not remain behind: because thingness was only a fiction added by us, out of the needs of logic, thus for the purpose of designation, communication (…).

The philosopher considered the concept of thing-in-itself empty because every “thing”, as language construction, depends on humans, it is related to humans. The German thinker criticized the notion of thing as well in a passage where mathematics and the classical logic, or the principle of identity, are attacked.

The invention of the laws of numbers was made on the basis of the error, dominant even from the earliest times, that there are identical things (but in fact nothing is identical with anything else); at least that there are things (but there is no “thing”).

According to Nietzschean philosophy, a specific “thing” is a human creation. More specifically, it is a creation from the human body—it depends on the body structure. For Nietzsche,
“thing” is an interpretation of becoming. Nietzsche followed Heraclitus and adopted the same point of view from the Ephesus thinker. That is, the Nietzschean world view in his maturity is Heraclitean in some degree. The world is interpreted as becoming, i.e., the nature of the world is change, process, flux or wills to power struggling. Therefore, Nietzsche assumes Heraclitus’ river image or, at least, the Platonic interpretation of Heraclitus. In Ecce homo, the German philosopher wrote on his Dionysian philosophy and his affinity with Heraclitus’ philosophy:

The affirmation of passing away and destruction that is crucial for a Dionysian philosophy, saying yes to opposition and war, becoming along with a radical rejection of the very concept of “being” – all these are more closely related to me than anything else people have thought so far.

For his Dionysian philosophy, a particular “thing”, or individual, appears as a “clipping” from becoming, and the concept of “being” as something stable is only the desire to refuse the total becoming, according to Nietzsche in Twilight of the idols: “(...) Heraclitus will always be right in thinking that being is an empty fiction”.

Therefore, in this perspective, a totally isolated object, or individual, such as a free particle (an extreme act of individuation in physics), and something stable such as “being” are only chimeras.

The river image, or metaphor, provides an argument against time machines. First of all, time machines, or travels into the past, assume full processes of individuation because human travelers are considered as isolated, static beings and detached “things” from becoming, from the universal flux. Supposedly, the traveler through a CTC (such as the curve $\gamma$) would return to another point “over the river”, interacting with another historical time and context, or another milieu as Simondon called. But in the river image, to abandon becoming and to travel into the past are impossible. The belief in some type of complete individuation—provided by an interpretation of individuation as non-process, supposedly generated by the principle of individuation—leads to the belief in humans as something detached from becoming, or from some type of context. The river picture, and essentially the becoming perspective, reveals such a hypothetical travel as science fiction because the full individual—as a “free particle”—and the concept of “being” as something stable are fable.

philosophy. And body in Nietzsche means mind, spirit as well: “Of all that is written I love only that which one writes with his blood. Write with blood, and you will experience that blood is spirit”, Nietzsche (2006, On reading and writing).

For Nietzsche, “becoming, effecting, is only a result” of wills to power. Because a singular will to power (Wille zur Macht) is a quantum of power with intention of increasing power. In another fragment, the philosopher wrote: “All that happens, all movement, all becoming as a determining of relations of degree and force, as a struggle...” That is, “This world is the will to power — and nothing besides!” An introduction to this subject, specially dedicated to physicists, is found in Neves (2016) and Neves (2015).

The Nietzschean view on the war was constructed from the Greek concept of agon. In an initial text, The Homer’s contest of 1872, the young Nietzsche emphasizes the dispute as a Leitmotiv in the ancient Greek culture.

This is another metaphor. A “real” traveler through $\gamma$ would experience tidal forces during a hypothetical time travel. The term “free particle” here indicates only the isolated individual from any context.
The full individual is not an \textit{aeterna veritas} (eternal truth)\textsuperscript{25}, is not apart from the universal flux.

The pictorial argument presented in this article—the becoming point of view—does not deny the time paces described in Special Relativity or in General Relativity, given by the gravitational redshift. Such as on the ordinary river, the flux in Heraclitus’ river is not invariant. In a real river, the fluid velocity depends on the position and depth. A mass of water (an “individual” or “being” in this example) has different velocities if its position is close or not to the margin, or at a great depth, for example. The time dilation given by Lorentz’s transformations would be assured in Heraclitus’ metaphor because the universal flux is not ever the same. But CTCs or time machines would be ruled out.

The dear reader could ask me about the possibility of traveling over an ordinary, or real river. By using a boat, for example, a traveler could reach any point over a real river. However, in this example, the boat does not make part of the flux. In this argument, the boat is considered something firm, a stable “being”—something different from becoming. But Heraclitus taught us that “all things are in motion”, or that all things flow, and thus spoke Zarathustra in a brilliant passage where the Ephesus philosopher and his doctrine are indicated:\textsuperscript{26}

\begin{quote}
If timbers span the water, if footbridges and railings leap over the river, then surely the one who says “Everything is in flux” has no credibility.

Instead, even the dummies contradict him. “What?” say the dummies, “everything is supposed to be in flux? But the timbers and the railings are \textit{over} the river!

Over the river everything is firm, all the values of things, the bridges, concepts, all ‘good’ and ‘evil’ – all of this is firm!” –

But when the hard winter comes, the beast tamer of rivers, then even the Wittiest learn to mistrust, and, sure enough, then not only the dummies say: “Should everything not – stand still?”

“Basically everything stands still” – that is a real winter doctrine, a good thing for sterile times, a good comfort for hibernators and stove huggers.

“Basically everything stands still” – but against this preaches the thaw wind!

The thaw wind, a bull that is no plowing bull – a raging bull, a destroyer that breaks ice with its wrathful horns! But ice – breaks footbridges!

Yes my brothers, is everything not now in flux? Have all railings and footbridges not fallen into the water? Who could still hang on to “good” and “evil”?

“Woe to us! Hail to us! The thaw wind is blowing!” – Preach me this, oh my brothers, in all the streets!
\end{quote}

\textsuperscript{25}All philosophers have the common failing of starting out from man as he is now and thinking they can reach their goal through an analysis of him. They involuntarily think of ‘man’ as an \textit{aeterna veritas}, as something that remains constant in the midst of all flux, as a sure measure of things”, \textit{Nietzsche} (2005a, 2).

\textsuperscript{26}\textit{On old and new tablets}, 8).
4 Final remarks

Closed timelike curves (CTCs), or time machines, are objects within General Relativity. There are some metrics, or spacetimes, with CTCs as solutions of (non)-geodesic equations in Einsteinian theory. The van Stockum’s solution and the Gödel’s cosmological model are examples of solutions of Einstein’s field equations with possible CTCs. Authors have proposed physical and philosophical arguments to exclude CTCs as physical realities and its paradoxes. However, a strong, general and persuasive argument to ban the travel into the past is missing today in physics and philosophy. Arguments such as Hawking’s Chronology Protection Conjecture show that ingredients beyond General Relativity are necessary to reject time machines. Thereby, this paper presents an argument against time machines that comes from philosophy. Individuation thought of as a non-process, supposedly generated by a metaphysical principle of individuation, motivates the belief in human beings who would travel into the past. In an exaggerated degree, individuation as non-process gives rise to the belief in human beings as isolated beings, as separated from their contexts and milieus. An individual emerges from a society, culture with values and language and from a specific historical time. The belief in the complete individuation ignores such a condition, dreaming with humans as “free particles” traveling into the past. Then, denying individuation as non-process, using Heraclitus’ river image, where “everything is in flux”, and Nietzsche’s “radical rejection of the very concept of ‘being’”, time machines appear as subject of science fiction, and CTCs rise as nonphysical objects of Einstein’s theory of gravity.

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