

Andrej Ule, Ljubljana

Univerza v Ljubljani, Filozofska fakulteta, Aškerčeva 2, SI-1000 Slovenija
andrej.ule@uni-lj.si

Einstein, Gödel and the Disappearance of Time

Abstract

The author discusses Gödel's cosmological proposals that seemingly allow time-loops and time-travel, and particularly Gödel's thesis that the objectivity of time-lapse is not guaranteed a priori but depends on the physical conditions in a cosmos. We could not 'define' a uniform world time-line regarding the mean state of motion of matter but some relative and partial time lapses which would appear as simultaneous for other observers. The author believes that consciousness may possess many time-modalities, and the 'annihilation' of lapse of time is one of them. It could be that already the momentary recollection of the past events in our mind might indicate such a possibility. However it is an open question what this possibility means for the physical reality, or for the 'cosmos itself'?

Key words

Kurt Gödel, Albert Einstein, time lapse, time travel, simultaneity, relativity

Kurt Gödel wrote at the end of Fourth three short texts on the Relativity theory which are based on his extensive discussions with Einstein in Princeton (Gödel, 1990a, 1990b, 1990c). The articles are interesting but they didn't arouse any considerable interest on the part of other physicists at that time. They seemed too strange and even speculative although Einstein himself was very much interested in Gödel's ideas. Gödel was also one among those rare persons who could accompany Einstein on his famous walks through the Princeton campus and hold discussions with him. One of Gödel's text also appeared in Schilpp's famous Einstein volume to the *Library of Living Philosophers* (Schilpp, 1970; Gödel, 1990b). Einstein has positively commented Gödel's article, and accepted his idea of the closed time-line as a physical possibility.

Gödel's articles later piqued the living interest of those physicists, philosophers and especially science-fiction writers who were dreaming about the possibility of time travel to the past. He was one of the first scientists who proved the physical possibility of time travel to the past. But this wasn't the central topic of his research in the relativity theory. He had deeper philosophical ambitions, namely to prove the 'ideality' or unreality of time. Or more precisely, he tried to prove the unreality of the lapse of time, that is, the 'flow of Nows', and the constant changing of the possible future into lively present and into fixed past. He compared this aim to the 'idealistic' concepts of time, first of all with the Kantian transcendental views on space and time (but he mentioned Parmenid and McTaggard, too) (Gödel, 1990b, p. 202).

In 1949 Gödel put forward some quite unusual solutions to Einstein's equations of general relativity. The solutions known before were Einstein's solution, which stated an unchanging and eternal universe, de Sitter's flat-space

solution and Friedman's solution, which allowed the expanding (or contracting) universe born at a certain moment in the finite past, later known as the *Big bang model* (Torretti, 1999, p. 301–302). The later solution soon became widely accepted because it was consistent with the known astronomical data, especially with Hubble's discovery of the redshift of light spectra for distant galaxies (it suggested the expansion of space). Gödel's solutions allow the rotating universe. In this model the centrifugal force arising from the rotation is in balance with the force of gravity which presses celestial bodies towards the collapse. An observer in this universe would see all galaxies slowly spinning around him. He wouldn't feel any dizziness, and this shows that the universe and not he is doing the spinning. This seems a bit weird. Gödel proposed two variants of this model, a static model (the universe is only rotating with a constant angular velocity) and a dynamic, which allows the expanding universe. In these models there does not exist a common time-line for all the universe which would fit all possible observers and their local times into one world time. In the Einstein's and Friedman's universe it is possible to determine such time, namely through the mean motion of matter. In our universe we have to consider some large regions of the universe and to determine the mean motion of matter in this region. For example, we can determine the mean movement of many galactic systems around us and assume that the 'true mean motion' isn't much different from this measured mean value. Gödel claimed that in some of 'his' universes (in the 'static' universe) such a symmetry does exist and that for each possible concept of simultaneity and succession there exist others that cannot be distinguished from it by any intrinsic properties, but only by reference to individual objects, such as, for example, a particular galactic system (Gödel, 1990b, p. 204). Accordingly we cannot give an objective physical sense to the very concept of change.

In Gödel's 'static' universe there also exists the possibility of some closed time curves. When someone progresses forward in time (that is, into his future) along a geodesic curve, one arrives back at one's starting point. Strictly speaking, he travels ever to the future but he ends in the past! There exists, at least in principle, the possibility of 'round trips' on a rocket ship into the present, future or the past and back again further, the same as it is possible in our world to travel to distant parts of space.

Gödel indicated some paradoxes of the trip to someone's own past, for example, the case that someone does something to himself at some earlier period of his life what by his memory has not happened to him. It is true that this possibility exists only in principle because of the technical difficulties involved (the velocity near to the velocity of light, a very high acceleration, and an enormous amount of fuel). However, for a voyage into some other past region of the universe we would need even much less velocity and energy (ibid.). In any case, at least in some of Gödel's universes the meaning of an objective lapse of time would lose every justification. In whatever way one may assume time to be lapsing, there will always exist possible observers to whose experienced lapse of time no objective lapse corresponds. Also, the meaning of simultaneity loses an objective meaning. We have the experience of the lapsed time without an objective correlate in the universe.

Gödel concluded that this shows that there cannot be an objective lapse of time (Gödel, 1990a, p. 191). According to Gödel, this trait strengthens the 'idealistic' viewpoint on the unreality of time and its dependence on the human mode of perception and its kind of movement (Gödel, 1990b, p. 205). This means the 'disappearance of time'.

Someone would say that he tried only to give a new proof of the unreality of the so-called A-series of events (according to McTaggart), that is, the series of Nows which ‘appear’ from the future and vanish into the past, and that B-series, that is the linear ordering of time events according to *earlier-later* relationship, are still O. K. But truly speaking, because of the possibility of ‘traveling to past’, he attacked also the concept of linearly ordering of time, that is the B-series. The impossibility of the mean cosmic time-line in Gödel’s universes and closed time courses threatens the *objectivity* of B-series too.

Someone could object that very probably Gödel’s static universe isn’t our universe, because of the strangeness of its physical conditions. It is only a strange physical possibility, so we cannot conclude that the lapse of time in our universe is unreal. Gödel knew this objection, and he answered shortly. He answered first that his solutions of Einstein’s equations also enable the existence of some more realistic rotating universes, namely the expanding rotating universes (they know the redshift of light for distant objects) that do not have the possibility of travel into the past but they also don’t know an ‘absolute time’ in the described sense. There does not exist any mean time line defined regarding the mean movements of the matter for a large part of universe. It is not impossible that our world is a universe of this kind (Gödel, 1990b, p. 206, 1990c, 212–213). His second short answer to the objection is that the existence of an objective lapse of time depends on the particular way in which matter and its motion are arranged in the world, namely on the special Gödel’s conditions for a circulating universe. This is not a straightforward contradiction but it still has some unsatisfactory philosophical consequences (*ibid.*, p. 207). The second answer is a bit enigmatic. It can be said that our world is in principle indistinguishable from a universe in which objective lapse of time is demonstrably absent. The experience of lapse of time and the physical laws are the same in both cases. Does this mean that the time lapse is not real in our world either. Gödel seems to say “yes”.

It would be more accurate to say that Gödel meant that, strictly speaking, he proved the radical relativity of the lapse of time which leads us to the unreality of the lapse of time. It doesn’t mean only the usual relativistic meaning of ‘presents’ and ‘Nows’ in regard to the frames of reference of different ‘observers,’ but a deeper relativity in regard to the accidental ‘arrangement’ of the matter in our universe. Someone would say that this does not prove the unreality of time, but in a former remark to his text Gödel said that a relative lapse of time would certainly be something entirely different from the lapse of time in the ordinary sense, which means a change in the existing (Gödel, 1990b, p. 203, rem. 5). However, according to Gödel, the concept of existence, cannot be relativized because in such a case it loses its meaning completely. Existence and the lapse of time are absolute concepts, if they refer to something real.

A second objection is not valid either. This objection says that Gödel’s argument shows only that time lapses in different ways for different observers, or, as in our case, it lapses in different ways for different universes whereas the lapse of time itself may nevertheless be some intrinsic or absolute property of time or of reality. But this would still cancel the definiteness of the lapse of time. Gödel rejected this counter with the statement that a lapse of time, which is not a lapse in some definite way, seems to him absurd as a colored object which has no definite colors. Even if such a thing were conceivable, it again would be something totally different from the intuitive idea of the lapse of time in the usual or in the philosophical (idealistic) sense (*ibid.*).

In his very interesting book on Gödel and Einstein, Palle Yourgrau writes that Gödel's proof of the unreality of time presents a kind of negative ontological proof, using the possibility of unreality of time (in a physically possible universe) to prove the unreality of time in the actual universe (Yourgrau, 2005, p. 130–131). I'm not sure if this is correct, but it is an interesting idea.

The fundamental premises of this reasoning are the premises that the lapse of time has to be something definite (like existence), and that the lapse of time is definite if and only if it exists in all possible universes and in the same way (that is, as something non-relative). This resembles the hidden premise of the more famous ontological proof of God, namely that God as the perfect being is something definite if and only if it exists in all possible worlds and in some non-relative way. It is interesting that Gödel also tried to formulate his own very subtle version of the ontological proof of God (Sobel, 1987).

Yourgrau wrote that Gödel found that we can have a world in which there is time or a world in which there is existence, but not both. Gödel made the only rational choice: a world without time because existence is an absolute concept (Yourgrau, 2005, p. 132).

Gödel's proof of the unreality of time presupposes that general relativity and its cosmological models, but not our intuitive concepts of space and time, adequately represent existence or reality. However, we have to be careful when speaking about the unreality or disappearance of time because it means the unreality of intuitive and philosophical concept of time (time as an aspect or a measure of real existence), but not the unreality of the so-called time-dimension in the general theory of relativity (see Yourgrau, 2005, p. 135). The t variable in the relativity physics has to have another interpretation; for example, for Gödel it has some abstract spatial sense. The identification of relativistic time dimension with ordinary concept of time is reasonable in usual, everyday conditions but not in extreme geometrical environment or in the whole universe.

Yourgrau compared this Gödel's discovery with his famous proof of the incompleteness of formal arithmetic. Gödel proved the essential difference between provability and truth, and similarly he proved the essential difference between the relativistic t -dimension and the intuitive concept and experience of time (T) (ibid.). In both cases, he succeeded to prove his theses by constructing some extreme cases (an extreme case of formalization, an extreme solution of the equations of general relativity). Yourgrau compares further Hilbert's attempts to avoid the consequences of Gödel's incompleteness theorem and Hawking's attempts to get around the embarrassing consequences introduced by Gödel's universe. Hawking introduced the so called "chronology protection conjecture" which proposed a modification of general relativity whose primary goal was to rule out the possibility of universes that permit temporal loops and causal irregularities (Hawking, 1992).

Yourgrau believes it is something of a scandal that this similarity between the two Gödel's results has gone unnoticed for so long, and that philosophers did not recognize the deep meaning and consequences of Gödel's physical results (Yourgrau, 2005, p. 136–137). According to Yourgrau, there is an important difference between the two Gödel's results. The incompleteness proof does show that the devices of formal proof are too weak to capture all arithmetic truths. The relativistic proof similarly shows that the intuitive concept of time is too weak to be captured by general relativity. The intuitive concept of time simply does not agree with facts, and this indicates its unreality. For Gödel,

the term ‘subjective time’ is also just a euphemism, subjective time is simply an illusion (*ibid.*, p. 137).

It would be false to conclude that Gödel defends some form of Kantian’s idealism. In some sense, his view is not opposite to Kant’s. For Kant, all empirical reality (that means space and time) crucially depends on some ‘mental’ faculties of human consciousness (that is, on pure intuition, pure space and time, and on pure reason, categories of reason). These transcendental forms constitute a universal framework for all objective scientific knowledge. For Gödel, empirical reality and the objectivity of science do not depend on anything like pure intuition or pure reason. Just the opposite! Gödel tries to show the radical departure of the relativistic concept of time from any intuitive idea of time and on the lapse of time (Stein, 1990, p. 200). Stein refers to Gödel’s unpublished manuscript on the relationship between theory of relativity and Kantian philosophy. Gödel wrote there that Kant overemphasized the dependence of spatiotemporal structure upon our faculty of representation, and that this led him to make two errors. The first was that he concluded, erroneously, that the temporal properties of things (events) must be the same for all human beings, and the second was that he failed to see that geometry is at least in one sense an empirical science (ref. in Stein, 1990, p. 200).

There is some similarity between Kant and Gödel in regard to the dependence of empirical temporal properties on the sensibility of the observer; in Kant, it is the dependence on some transcendental forms of human perception, and in Gödel, the dependence on the world-lines of human bodies (Stein, 1990, p. 201). Stein reports that Gödel wrote in a letter that he believed we have in some sense an *a priori* “physical intuition” of spatial structure “in the small” (*ibid.*) It seems that he believes that this intuition is basically correct, but we have not a similarly correct physical intuition of temporal structure. It is really a pity that we do not have more documents on the evolution of Gödel’s philosophical ideas on space and time.

What were Einstein’s answers to Gödel’s challenge? We know from his short comment on Gödel’s paper in Schilpp’s volume that Einstein believed Gödel’s paper constituted an important contribution to the general theory of relativity, especially to the analysis of the concept of time (Einstein, 1970, p. 478). He acknowledged that this problem always disturbed him although he never succeeded in clarifying it. It goes for the question of what makes the asymmetry of time. Is it always so that time-point B which lies in the ‘past’ part of Minkowsky diagram for a world point P has to be before any point A which lies in the ‘future’ part of the diagram? It seems obviously so because it is possible to send a signal from B to A but not from A to B. The sending of a signal is an irreversible thermodynamic process which is connected with the growth of entropy. Asymmetry regarding time is not a general trait of physical processes. We know that elementary processes in microphysics are reversible. Einstein asked himself what would happen if the distance between B and A were far separated apart from each other. Would the assertion ‘B is before A’ still make sense? Einstein said “certainly not, if there exist point-series connectable by time-like lines in such a way that each point precedes temporally the preceding one, *and if the series is closed in itself*” (*ibid.*, p. 688). In that case the distinction ‘earlier-later’ loses its meaning, at least for world-points which lie far apart in a cosmological sense. Einstein did not want to speak on philosophical consequences of Gödel’s results but he believed that his results were important. He asked on the end if there were some physical grounds that excluded Gödel’s solutions of the gravitation-equations (with non-zero cosmological constant).

Einstein did not mention the more ‘philosophical’ Gödel’s conclusions about the unreality of time. It is certain that in the case of some physical grounds that would exclude Gödel’s solutions his conclusions would be quite empty. Some physicists tried to prove certain mistakes in Gödel’s reasoning and calculations all such attempts have failed (Yourgrau, 2005, p. 119–121). As I have mentioned above, Gödel attacked the concept of lapse of time with the ‘flowing’ experience of Now as something real, and not the idea of time dimension and the time metrics in relativity physics. The time-dimension is not necessarily linked with the flow of time for some possible observers. At first sight, it seems that this is something trivial because at least physics (and scientific cosmology) should be free from all particularities on the side of actual or potential observers. But Gödel wants something more, namely the embedding of physical time in space, and discharging it from ‘experienced’ time. Sure, in some sense this was the ambition of Einstein too, and relativity physics presents, at least in its mathematical formulations, some kind of ‘spaciating’ of time. We know how vigorously Bergson protested against it and unhappily tried to defend the experienced (lived) time as the only real time before the physical time (Bergson, 1965). But, to my knowledge, Einstein never denied the reality of experienced time, nor did he deny the physical meaning of simultaneity and the experienced intervals of time for the observer. However, physical reality of simultaneity and intervals of time does not imply the physical reality of experienced Now and the lapse of time.

It is interesting that Einstein himself felt somewhat uneasy regarding the status of “Now” in physics. Carnap reported in his intellectual autobiography that Einstein told him once that the problem of the Now worried him seriously. For him, the experience of the Now meant something special for man, something different from the past and future, but this important difference does not occur within physics (Carnap, 1963, p. 37). This situation was somewhat painful for him. Carnap responded to Einstein’s remark by saying that all that occurred objectively could be described in science; on the one hand, the temporal sequence of events is described in physics; and on the other, the peculiarities of man’s experiences with respect to time can be described, and in principle explained, in psychology. Einstein answered that these scientific descriptions could not possibly satisfy our human needs; that there was something essential about the Now which is just outside the realm of science. Carnap thought that science in principle can say all that can be said, and that there is no unanswerable question left. But while the thought that there was no theoretical question left, there was still the common emotional experience, which was for him something disturbing for special psychological reasons (*ibid.*, p. 38). Here we have to distinguish between the simultaneousness of events with a given event in our time line and the ‘living Now’. Theory of relativity and physics generally consider the first but not the latter. This difference indicates the possible distinction between a Now as a constitutive part of our time experience and the physical reality of simultaneity.

We can see the important difference between Einstein and Carnap. Einstein was somehow interested in the reality of Now, while Carnap tried to sink it in the objectivity of events, scientifically described and explained. Steven Savitt comments the difference between Einstein and Carnap as the difference between the Heraclitean and Parmenidean attitude towards time and change (Savitt, 2005). It is interesting that this impression goes against the popular idea about Einstein’s conceptions of time. It is usually represented as quite ‘Parmenidian’, indeed as a kind of eternalism. In the general relativity theory,

time is represented as a dimension in the four-dimensional wholeness of the space-time reality where ‘all times’ are somehow simultaneously included and all events on one time-line (past, present and future) hold as real and even atemporally given. Sure, it is only a mathematical representation, which we do not have to understand directly, but still, it emphasized the Parmenidian outlook on time.

Let me now proceed to some final thoughts. Rather than putting forward some positive or negative theses, I prefer to express these thoughts in the form of challenging questions.

Gödel and some other prominent critics of the human perception of time as physically relevant phenomenon often refer to the radical relativism of time perception. Different observers who move in different way ‘feel’ different events as simultaneous, past or future. What one observer may perceive as being simultaneous with another event, another observer may perceived as past or even as future.

If we believe, like Gödel, in the possibility of moving along closed time courses and traveling into the past, then even one and the same observer could perceive the same event as occurring in the present, then in a ‘later’ moment as something that happened in the past, and still later (after finishing the trip in the distant future along a whole closed time line and finishing the trip just a bit ‘before’ the time-point of the given event) as a future event (Ule, 2001). For many critics of time travel, this means something absurd. It defies the causal order. The disturbance of causal order seems still more acute in the case of intervening in the past (Davies, 1995, ch. 11).

It seems strange, but is it really so strange that we should have different experiences of the lapse of time even in the case of the same events? I suggest the possibility of different ‘perceptions’ of time for the same observer.

The difference between past, present and future enables our way of doing and intervening in the world. It makes us responsible for our past deeds. If the experience of the lapse of time pertains to our consciousness of time, then we have to take it as *part our way, how to be temporal*, not only how to perceive or conceive of time. It orients us towards time, or better, it orients us towards events and ourselves as temporal beings. I assume that there is not only one way of how to be temporal and how to conceive of time. I believe that our consciousness may possess many modalities of temporality. The usual modality is the standard feeling of the lapse of time, but it is not the only one. We can feel something like the temporary ‘annihilation of time-lapse’. This feeling does not appear only in some peak or border experiences like ecstasies, drug-induced experiences states, meditative states etc., but also in the momentary recollection of the past events in our mind. We often recollect past events *together* with their lapse of time, and not as something *in* the lapse of time.

We do not feel them like lapsing in time but rather as a unit of *past* events. We usually do not recollect some ‘past’ Now, ‘past’ future and ‘past’ past but past events as whole. The experience of the lapsing of an event in time retreats to the background, and we are aware of it as the unit of past event. Sure, we can sometimes recollect some events more vividly, for example if we are recollecting some traumatic or dear events. It seems as if the past has ‘come’ back before us as something present, and it happens again. We usually know that this is only a psychological illusion, and that real events happened some time ago.

The most interesting mode of the temporary not-lapsing time consciousness for me are the cases of dissociation of the present from the momentary Now.

Such cases indicate that the link between the present and the instantaneous Now is not necessary. It happens sometimes in the cases of total concentration on something. It seems as if everything that we are doing or experiencing stays present, although formally it is sinking into the past or is anticipated in the near future. It would be false to say that such kind of time consciousness means something like ‘eternal Now’. It means rather some ‘eternal presence’ or a constant recollection of the present.

However, it is an open question what this dissociation means for the physical reality, or for the ‘cosmos itself’. Could it mean the transcending of the lapse of time and a more objective relationship to the time dimension of the four-dimensional wholeness, or just the opposite, some new, even more subjective illusion of time and tenses? Gödel, for example, was a Platonist in mathematics and he believed that for us mathematical truths are conceivable through a kind of conceptual intuition which somehow ‘grasps’ them in their ideal presence. Perhaps he would support the idea that the rare experiences of temporary prolonged presence of events is a more objective conception of the space-time manifold than the usual experiences of the lapse of time. In this case, Gödel’s argument for the unreality of time proves at most that the usual perception of the lapse of time does not correspond to the cosmological reality, but does not prove that the human awareness of time is simply wrong or subjective. It also does not prove that the time does not exist in reality but only in our consciousness.

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Andrej Ule

Einstein, Gödel und das Verschwinden der Zeit

Zusammenfassung

Der Autor setzt sich mit Gödels kosmologischem Ansatz auseinander, der scheinbar Zeitschleifen und Zeitreisen erlaubt, sowie insbesondere mit seiner These, dass die Objektivität des Zeitablaufs nicht a priori gegeben ist, sondern von physikalischen Bedingungen im All abhängt. Wir könnten keine einheitliche Weltzeitlinie in Bezug zum mittleren Bewegungsstatus der Dinge „definieren“, sondern nur einige relative und partielle Zeitabläufe, die den Betrachtern als gleichzeitig verlaufend vorkommen würden. Der Autor hinterfragt die Möglichkeit verschiedener „Zeitwahrnehmungen“ für denselben Betrachter: einmal da, wo der Zeitverlauf eine gewöhnliche „Bewegung“ wäre und die Vergangenheit der Gegenwart vorausgeht (bzw. die Gegenwart der Zukunft), und wiederum dort, wo dieser Verlauf gewissermaßen simultan wäre. Er vertritt die Meinung, dass das Bewusstsein viele Zeitmodalitäten besitzen kann und dass die „Annihilierung des Zeitablaufs“ eine davon wäre. Vielleicht deutet gerade die momentane Besinnung auf vergangene Ereignisse in unserem Geist auf diese Möglichkeit hin. Allerdings bleibt die Frage offen, was diese Möglichkeit für die physikalische Realität oder für den „Kosmos selbst“ bedeutet.

Schlüsselwörter

Kurt Gödel, Albert Einstein, Zeitschleifen, Zeitreisen, Simultaneität, Relativität

Andrej Ule

Einstein, Gödel et la disparition du temps

Résumé

Dans cet article seront examinées les propositions cosmologiques de Gödel qui de façon apparente autorisent les boucles temporelles et les voyages à travers le temps, et surtout sa thèse selon laquelle l'objectivité du cours du temps n'est pas a priori garantie, mais elle dépend des conditions physiques dans l'univers. On ne peut « définir » la ligne du temps uniforme et mondiale par rapport à l'état moyen du mouvement de la matière, mais des cours du temps relatifs et partiels qui apparaîtraient simultanés aux observateurs. Je pose la question de la possibilité des perceptions différentes du temps pour un même observateur, à savoir une perception là où le cours du temps serait un « mouvement » ordinaire et où le passé précède le présent (de même que le moment présent précède le futur) ainsi que d'une autre perception là où ce cours du temps serait d'une certaine manière simultané. Je suis d'avis que la conscience peut avoir de nombreuses modalités de temps dont l'annihilation du cours de temps. Peut-être que le souvenir momentané des événements passés renvoie, dans notre esprit, à une telle possibilité.

Or, la question de la signification de cette possibilité pour la réalité physique et l'univers même reste ouverte.

Mots clés

Kurt Gödel, Albert Einstein, cours du temps, voyages à travers le temps, simultanéité, relativité