Beyond Gödel's Time

Peter Riggs

/ *Letters*

In response to "Time Travelers" by Alasdair Richmond (Vol. 3, No. 4).

To the editors:

Alasdair Richmond's essay about Kurt Gödel's innovative solution to the Einstein field equations is a lucid exposition of a theoretical model of the universe.[1] The model, known as Gödel space-time in the technical literature, displays an intrinsic rotation of matter, which is responsible for some fascinating characteristics, but does not exhibit an expansion, as is the case with the actual universe. Nevertheless, it is clear that models with both rotation and expansion are also theoretical possibilities. Such models have been ruled out on empirical grounds because precise measurements have shown that the actual universe does not rotate.[2] These findings do not detract from the issues raised in the context of Gödel space-time. It is still a theoretical model of a possible, though not the actual, universe.

There are two features of Gödel space-time that have been discussed at length:

1. The existence of closed timelike worldlines; and
2. The lack of a globally consistent time ordering of events.

In some space-time models, closed timelike worldlines are paths that wind back in time. They allow for an object to visit an event in its past without exceeding the local speed of light. It is this feature that permits backwards time travel in Gödel's model. Following the publication of Gödel's model in 1949, other theoretical methods of time travel have been put forward that do not require a rotating universe.[3] Our current understanding of the laws of physics does not exclude the possibility of time travel to the past.[4] Whether or not backwards time travel will eventually be ruled out by physics remains an open question.[5]

Gödel assumed that everyday experience is the basis for our conception of time. This is known as the common-sense view of time, or dynamic time. The present moment is objective. Time lapses, or passes, as a succession of present moments.[6] With regard to the second feature of Gödel's model, further explanation of the phrase "globally consistent time ordering of events" is warranted. Suppose that we are travelling on a closed timelike worldline and that we discover an event, A, on this worldline that is before another event, B. This sequence is the time ordering relationship between the two events. In turn, we will also discover that the time order over a large region of the space-time—i.e., from a global perspective—is that event A is, in fact, after event B. This is because a closed timelike worldline turns back on itself.[7] The time ordering of events is therefore not globally consistent in space-times containing closed timelike worldlines. Gödel space-time is one such example.

In a book of essays devoted to Albert Einstein published in 1949, Gödel employed this second feature in order to draw the curious conclusion that time is ideal, as hypothesized by philosophers such as Immanuel Kant.[8] These philosophers held experience to be mind-dependent to the extent that there is no independent reality. Gödel's conclusion has been interpreted as meaning that time is unreal and does not have an objective existence. This is a conclusion that would not be accepted by most philosophers, nor, in fact, by most people, and was debated vigorously over the following decades.[9]

Richmond's essay only touches briefly on Gödel's argument against the reality of time. Consider the following basic outline of his argument and some responses that do not require time to be unreal.

The premises:

- Gödel space-time is a model of a possible universe.
- Time has an objective existence in all possible universes.
- Gödel space-time does not possess a globally consistent time order.
- A global lapse, or passage, of time is a necessary property of time and must be common to all possible universes.

The conclusion:

- Since Gödel space-time does not have an objective universe-wide lapse of time, which requires a globally consistent time order, and such a lapse of time is necessary in any possible universe, then time does not objectively exist.

The conclusion requires the denial of the second premise. If we accept that Gödel's conclusion follows from the premises and that this conclusion is false, then one, or more, of the other premises must be false. The first premise seems legitimate because Gödel space-time arises as a valid solution to the Einstein field equations. Given that the first premise is valid, the third, which states a property of Gödel space-time, is also valid. If we reject the second as false, that leaves only the fourth premise.

How the fourth premise is dealt with depends on the view of time that is utilized. If the common-sense view of time is accepted, one approach is to deny that the lapse of time is universe-wide, but still retain a notion of time passing. The lapse of time can be construed as an objective local phenomenon.[10] It is the local lapse of time that gives rise to our conscious experience of the passage of time—our everyday insight provides a correct conception of time.

The main alternative to the common-sense view of time is known as eternalism, or block time. According to this approach, there is no objective present moment, nor any lapse of time.[11] Although advocates of eternalism acknowledge that we all have an apparent experience of the passage of time, they take this temporal experience to be illusionary. In the context of eternalism, the fourth premise is obviously false; therefore Gödel's conclusion is also false. But this response introduces other complications; and in particular, accounting for the experience of time's passage without any physical lapse of time. This has proven to be extremely difficult and remains a major impediment to eternalism's broader acceptance. Nevertheless, recently published explanations for the experience of time's passage within this framework are encouraging.[12] Describing these explanations in sufficient detail would be a step too far beyond the current discussion and will have to wait for another time!

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1. Kurt Gödel, "An Example of a New Type of Cosmological Solutions of Einstein's Field Equations of Gravitation," *Reviews of Modern Physics* 21, no. 3 (1949): 447–50. Reprinted in Kurt Gödel, *Collected Works Volume II: Publications 1938–1974*, eds. Solomon Feferman et al. (Oxford: Oxford University Press, 1990), 190–98.
2. Daniela Saadeh et al., "How Isotropic is the Universe?" *Physical Review Letters* 117, no. 13 (2016), doi:10.1103/PhysRevLett.117.131302.
3. Kip Thorne, *Black Holes and Time Warps: Einstein's Outrageous Legacy* (New York: W.W. Norton, 1994); J. Richard Gott, *Time Travel in Einstein's Universe: The Physical Possibilities of Travel Through Time* (Boston: Houghton Mifflin, 2001); Brian Clegg, *Build Your Own Time Machine: The Real Science of Time Travel* (London: Duckworth Overlook Pubs., 2011); Jim Al-Khalili, *Black Holes, Wormholes & Time Machines*, 2nd edn (Boca Raton, FL: CRC Press, 2012).
4. John Earman et al., "Do the Laws of Physics Forbid the Operation of Time Machines?" *Synthese 169* (2009): 91–124.
5. In light of the summary of Gödel's model provided in Richmond's essay and the volume of published literature devoted to time travel and its alleged paradoxes, this letter will not discuss further the existence of closed timelike worldlines. The reader is instead referred to the following references:
   - Nicholas Smith, "Bananas Enough for Time Travel?" *British Journal for the Philosophy of Science* 48 (1997): 363–89;
   - Peter Riggs, "The Principal Paradox of Time Travel," *Ratio* X (1997): 49–64;
   - Paul Nahin, *Time Machines: Time Travel in Physics, Metaphysics and Science Fiction*, 2nd edn (New York: American Institute of Physics, 1999);

- David King, "Time Travel and Self-Consistency," *Ratio* XII (1999): 271–78;
- Jenann Ismael, "Closed Causal Loops and the Bilking Argument," *Synthese* 136 (2003): 305–20;
- David Horacek, "Time Travel in Indeterministic Worlds," *The Monist* 88 (2005): 423–36;
- Christopher Smeenk and Christian Wüttrich, "Time Travel and Time Machines" in *The Oxford Handbook of Philosophy of Time*, ed. Craig Callender (Oxford: Oxford University Press, 2011);
- Douglas Kutach, "Time Travel and Time Machines" in *A Companion to the Philosophy of Time*, eds. Adrian Bardon and Heather Dyke (Chichester: Wiley-Blackwell, 2013);
- Giuliano Torrengo, "Time Travel and Coincidence-Free Local Dynamical Theories," *Synthese* (2017), doi:10.1007/s11229-017-1433-9.

6. Barry Dainton, *Time and Space*, 2nd edn. (Durham: Acumen, 2010), 13–25.
7. John Earman, *Bangs, Crunches, Whimpers, and Shrieks: Singularities and Acausalities in Relativistic Spacetimes* (New York: Oxford University Press, 1995), 22.
8. Kurt Gödel, "A Remark about the Relationship Between Relativity Theory and Idealistic Philosophy" in *Albert Einstein: Philosopher-Scientist*, ed. Paul A. Schilpp (Evanston, IL: Library of Living Philosophers, 1949), 557–62. Reprinted in Kurt Gödel, *Collected Works Volume II: Publications 1938–1974*, eds. Solomon Feferman et al. (Oxford: Oxford University Press, 1990), 202–207.
9. See, for example: John Earman, *Bangs, Crunches, Whimpers, and Shrieks: Singularities and Acausalities in Relativistic Spacetimes* (New York: Oxford University Press, 1995), 196–200.
10. Dennis Dieks, "Becoming, Relativity and Locality" in *The Ontology of Spacetime*, ed. Dennis Dieks (Amsterdam: Elsevier, 2006), 172–73.
11. Barry Dainton, *Time and Space*, 2nd edn. (Durham, U.K.: Acumen, 2010), 27–43.
12. Simon Prosser, Experiencing Time (Oxford: Oxford University Press, 2016); Peter Riggs, "The Perceptions and Experience of the "Passage" of Time," *Philosophical Forum* 48 (2017): 3–30; Giuliano Torrengo, "Feeling the Passing of Time," *Journal of Philosophy* CXIV (2017): 165–88.