GÖDEL MEETS EINSTEIN: TIME TRAVEL IN THE GÖDEL UNIVERSE. By Palle Yourgrau. Chicago: Open Court, 1999. Pp. xiv, 253.

In 1949, Kurt Gödel (1949) found a solution to the field equations of general relativity which described a spacetime with some unusual properties. This 'Gödel universe' permitted 'closed timelike curves,' hence a kind of time travel, and it did not admit decomposition into successive moments of time. In the same year, he published "A Remark about the Relationship between Relativity Theory and Idealistic Philosophy" (Gödel 1949a) in which he used certain properties of this solution to argue for a kind of temporal idealism, whereby "change [is] an illusion or an appearance due to our special mode of perception" (202). The paper is short and to the point, but the argument has usually been regarded as fatally flawed. In his *Gödel Meets Einstein: Time Travel in the Gödel Universe*, Palle Yourgrau makes a case for Gödel.

Though one would not guess from the title, Yourgrau's book is actually the second edition of his *The Disappearance of Time: Kurt Gödel and the Idealistic Tradition in Philosophy* (1991). It must be said that the title of the first edition is more appropriate, as the focus of both editions is really on Gödel's argument for the ideality of time. The remark in the preface, that the second edition "explore[s] in much greater depth the question of 'time travel'," is somewhat inaccurate; more on that below.

The book proceeds by first setting the philosophical stage for Gödel's argument, placing his thinking about relativity theory into a wider context which includes his more familiar explorations in the foundations of mathematics. It then goes on to discuss the Gödel universe, which, Gödel argued, provided strong motivation for the belief that time is ideal. Following this is a chapter new to the second edition, which repeats and amplifies points made in the previous chapters, while also addressing the treatment of Gödel's argument in John Earman's *Bangs, Crunches, Whimpers and Shrieks* (1995), a book on foundational issues in general relativity. The last two chapters take a different turn, discussing the relevance of Gödel's views to issues arising in a variety of areas, including tense logic and modal logic. The appendices, both new to the second edition, contain discussions of potential vs. actual infinity, as these concepts arise in the work of Brouwer and Zeno.

Yourgrau is a zealous advocate for Gödel. One gets the idea that Gödel should be taken seriously, and that his views have been dismissed partly as a result of misunderstandings of his philosophical perspective, particularly his affinity for Platonic metaphysical analysis and his antipathy for positivism (broadly construed). Yourgrau is at pains to emphasize that Gödel's analysis of "time" is one which is not a positivistic or operationalist one, nor an ordinary-language one. Rather, Yourgrau emphasizes that Gödel thinks of time (and its companion-concept 'existence') as primitive, intuitive notions. Gödel's 'intuitive time' is time that involves a linear ordering of events in the world, and thus a meaningful sense in which these events lapse, or flow. Gödel's interest is in whether general relativity supports such a notion. If not, then a world described by general relativity is one in which time is "ideal".[1]

Interestingly, Gödel claims that the spacetime associated with *special* relativity is hostile to the notion of temporal passage. The issue arises because the flat, Minkowski spacetime of special relativity admits no unique or privileged decomposition into space and time, in other words, into a series of moments. Two inertial observers with different velocities will disagree on which events are simultaneous with which other events (at least if they use the Einstein simultaneity convention). Thus Gödel thinks that time cannot be said to "lapse" in a special relativistic world, because the lapsing (the series of moments) would be observer-relative. This means that there is no time because, "[e]ach observer has his own set of 'nows', and none of these various systems of layers can claim the prerogative of representing the objective lapse of time" (Gödel 1949a, 203). Gödel thinks that the existence of time requires successive events to come into existence and go out of existence, and that this must be an "objective" process.

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[1] As is often the case, 'ideal' is understood as a negative concept – ideal apparently means "not real" and "not objective." As Schlesinger (1993) points out in his review of the first edition, this is a common mode of characterization, but one might like something more.

If one concedes that objective passage, in the sense of observer-independent lapse of time, is required for a world to exhibit temporality, then it would indeed appear that the conventional interpretation of special relativity is at odds with temporality in the sense required. However, one may take the point of view of Lorentz**,** and arguably Bell (1976), whereby there *is* an objective lapse of time, that associated with some privileged family of inertial observers.[2] This privileged reference frame is empirically inaccessible but ontologically meaningful, unless one is some sort of verificationist, which Yourgrau is at pains to say that Gödel is *not*. Yourgrau mentions this alternative view at several points in the book, but seems undecided as to whether to regard it as an alternative *interpretation* of special relativity ("Gödel was very interested in the question of the Lorentz versus Einstein interpretation of the formalism of the STR" (109), or rather as an alternate though empirically indistinguishable theory ("the STR precisely denies that we are allowed to take any one reference frame (or point at a reference frame), as privileged" (56).[3]

If Gödel felt, as Yourgrau seems to suggest in much of the book, that special relativity is completely inhospitable to intuitive time, then it is hard to see why it was necessary to construct the Gödel universe, for although the Gödel universe is a general relativistic model, so, too, is the flat, vacuum spacetime of special relativity. Neither correspond to the structure of the universe we live in, and apparently neither is hospitable to the idea that time is something that lapses. What, then, is added by discussing the Gödel universe? Yourgrau does not say, though one might guess that Gödel was, after all, *not* fully convinced that special relativity precluded a preferred reference frame.

The argument for the ideality of time in special relativity is, again, that the spacetime may be decomposed into "instants" in many different ways (in other words, it admits *many* global time functions), but singles none out as privileged. Gödel concedes that this logjam might be broken in *general* relativity, where the structure of spacetime is affected by the arrangement of matter. (Although one can certainly conceive of matter breaking the symmetry in the flat spacetime of special relativity, as well.) As Yourgrau notes, our ordinary talk about the age of the universe presupposes just such a preferred time. But Gödel's solution gives an alternative, rotating universe, filled with matter, that admits *no* global time function. There is, *a fortiori*, no analog to the Lorentz/Bell reinterpretation of the theory which introduces a *preferred* frame.[4]

On the other hand, the relevance of Gödel's solution to the ideality of time in our universe is rather suspect, and Yourgrau provides little in the way of defense. The problem, essentially, is that it is unclear why the nonexistence (hence ideality) of intuitive time in the *Gödel* universe implies the ideality of time in the universe *we* inhabit. Earman (1995) attempts a charitable reconstruction of Gödel's argument from the possible (Gödel universe) to the actual (our universe), but concludes by saying, "I have been unable to locate any plausible argument which starts from Gödel's considerations and leads to the conclusion that time is ideal." As Savitt (2001) points out, Yourgrau never really addresses the crux of Earman's argument, which is that the modal step is unmotivated.

What, then, of time travel? Yourgrau provides a compact discussion of what time travel in the Gödel universe would amount to, taking care to point out that the closed timelike curves present in that universe represent a kind of circular time, if they represent time at all, rather than a cyclical (endlessly repeating) time. This is all to the good, though one might expect bit more discussion of the philosophical issues at stake in a book subtitled "Time Travel in the Gödel Universe."

On the other hand, one might excuse Yourgrau for not discussing time travel more extensively, for Gödel himself does not seem to be very interested in it. In fact, Gödel seems to suggest that the possibility of self-contradiction (the so-called "grandfather paradox") raised by time travel would be a real worry, were it not

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[2] Tooley (1997), like Bell (1976), also invokes considerations from quantum mechanics to argue for the plausibility of a privileged reference frame.

[3] Gödel makes some suggestive remarks on this issue in the last paragraph of his unpublished "Some Observations about the Relationship between Theory of Relativity and Kantian Philosophy" (Gödel 1946/1949C1, 259).

[4] One can foliate the spacetime by three-dimensional hypersurfaces which intersect each worldline (of the 'dust') only once, but these hypersurfaces will not be entirely spacelike. This means that there are causally connectable points on each surface, making them poor candidates for "instants of time".

for the fact that time travel in the Gödel universe is a practical impossibility. Yourgrau himself offers an admirably clear argument to the effect that such worries are specious (40-41), but fails to differentiate his view here from Gödel's, and thereby, it seems to me, gives improper emphasis to the importance of time travel to Gödel's concerns. Really, it seems to be the case that the significance of the closed timelike curves of the Gödel solution is simply to demonstrate the absence of a global time function. In discussing Gödel's argument for the ideality of time, time travel is a distracting sideshow.

The book on the whole has much to recommend it, as it combines serious engagement with a deeply difficult metaphysical issue with relevant facts from foundational explorations in physics. The case for Gödel is not entirely convincing, and the discussion of time travel is rather skimpy, but the book does succeed in bringing to the fore the problem of the nature of time in a world described by relativity theory, and would provide a useful text for an advanced course on these issues.[5]

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