

Spacetime 2

Christian Wüthrich

<http://philosophy.ucsd.edu/faculty/wuthrich/>

130 Metaphysics

Fall 2012

John McTaggart Ellis McTaggart (1866-1925)



- John McTaggart Ellis *McTaggart*
- educated and taught at Cambridge
- man of contradictions: started out as radical, became increasingly conservative (was instrumental in Russell's expulsion from Trinity College during WWI), yet advocated women's suffrage, was an atheist, yet firm believer in human immortality and staunch defender of Church of England...
- British idealism, influenced by Hegel
- 'The unreality of time', *Mind* **17** (1908): 456-473.

A-series and B-series

Characterization (A-series)

Events can be ordered by their relation to the 'now', i.e. how much they are 'past' or 'future' etc. Events have temporal properties such as 'three days ago', 'present', 'far in the future' etc. The order runs from the remote past through the recent past, the present, into the near future and finally into the far future. Pastness, presentness, futurity are basic A-properties. A-facts are transitory and A-sentences change truth values over time. The A-series is a dynamic temporal ordering.

Characterization (B-series)

Events can be ordered by binary, asymmetric, irreflexive, transitive relation of precedence. Thus, we have B-properties such as 'simultaneous with', 'earlier than', 'later than'. B-facts are eternal and B-statements are timelessly true or false. The B-series is a static temporal ordering.

McTaggart's master argument

Dainton, *Time and Space*, 14:

- 1 "If the A-series does not exist, then time does not exist.
- 2 "The A-series is metaphysically incoherent, and therefore does not exist.
- 3 "Therefore, time does not exist."

Establishing the first premise

Two premises are required in turn:

- 1 Time is the dimension of change, i.e. change cannot possibly occur in a world without time.
 - 2 Change requires the A-series, A-series offers the aspect of time that enables change.
- mere B-facts cannot constitute change: it is eternally true (or false) that a poker is hot at t_1 and cold at t_2 , *there is nothing changing about this*
 - A-series: poker's being hot at t_1 is first distant future, then near future, then present, then recent past...
 - Analogy: B-facts of variation in time are like spatial variation
- ⇒ A-series is essential to time.

Establishing the second premise

- event e , attributes past P , present N , future F ; thus, Pe , Ne , Fe
- these attributes are incompatible: e cannot be past and future
- But: all events have all three attributes!
- Obvious reply: events do not possess attributes *at the same time*, but successively: e was future, is present, will be past...
- Look at set of 'second-order' attributes: PFe , NNe , FPe , etc.
- McTaggart: set of all nine second-order attributes is inconsistent, yet all events have all of them!
- Reply: inconsistency can be resolved by using third-order attributes: $NPFe$, $NNNe$, $NFPe$, etc.
- McTaggart: at each level, set of attributes is inconsistent, yet all events have all of them!
- McTaggart: this regress is vicious.

Another version of McTaggart's argument

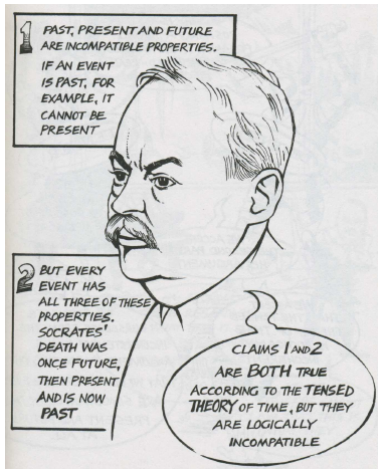


Figure: From: Callender and Edney, *Introducing Time*, Icon Books UK, 2001.

Tensors vs. detensors

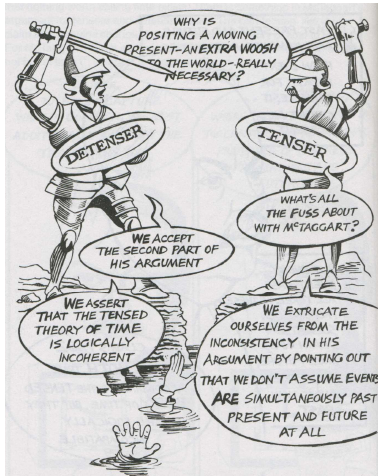
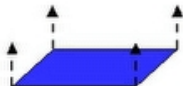


Figure: From: Callender and Edney, *Introducing Time*, Icon Books UK, 2001.

3 METAPHYSICS OF TIME

Presentism

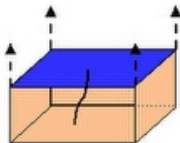
"Nowism"



The Present

Possibilism

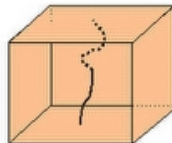
"The Tree Model"



Past & Present

Eternalism

"The Block Universe"



Past, Present, & Future

Presentism

Position (Presentism)

Presentism maintains that only present events and objects exist. Furthermore, it is usually assumed that there is a succession of presents, i.e. a moving Now.

Presentists face at least two major challenges:

- 1 The 'problem of the past': by virtue of what are propositions on past events true?
- 2 It seems to be incompatible with contemporary physics.

The problem of the past

Principle (Truthmaking principle)

"[A]ny contingent statements about the world that are true are true by virtue of something in the world that makes them true—their truthmaker." (Dainton, 80)

- ⇒ If the past doesn't exist, there are no past facts that could act as truthmakers.
- How can a presentist react?
 - One option: deny the truthmaking principle
 - Another: bite the bullet: there are no true statements about what happened in the past
 - More promising: there are truthmakers of statements about the past, but they all exist in the present.

Reductionism about the past

Two unpalatable consequences:

- 1 Since different presents contain different traces of the past, the past becomes unstable if it's defined by virtue of these traces.
- 2 Truths about the past are restricted by what exists now, i.e. sentences about past events whose traces have all been erased can no longer have any truth-value.

The pressure from SR: Putnam-Rietdijk argument

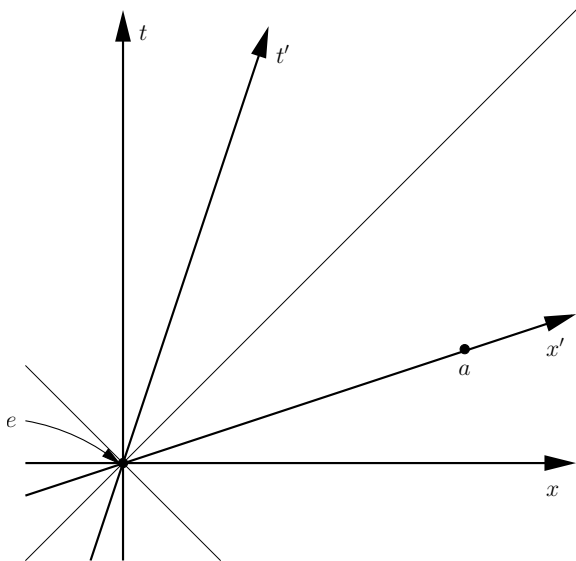
In a nutshell

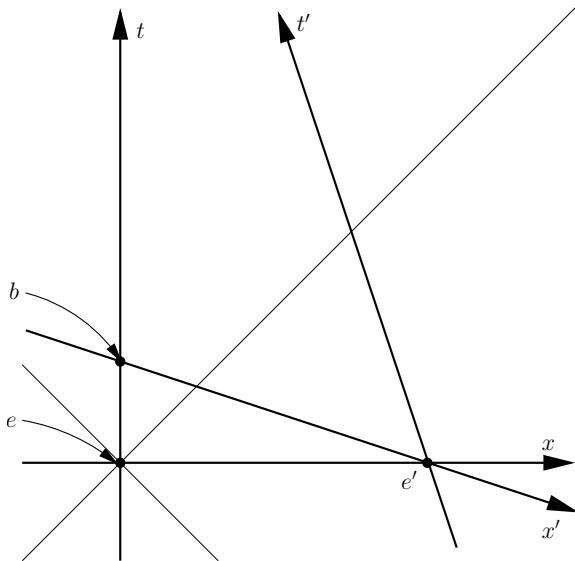
Putnam (1967) and Rietdijk (a bit earlier, see also Stein (1991)) proposed an argument that puts presentism, and similarly classical dynamical theories of time, under significant pressure. I think presentists do have a response to this sort of argument, at least in the particular form in which Putnam proposed it. But it is difficult for the presentist to escape the general thrust of the Putnam-Rietdijk argument without serious harm.

The Putnam-Rietdijk argument

The Rietdijk-Putnam argument has two crucial premises:

- 1 “The fundamental entity, relative to which the distinction of the ‘already definite’ from the ‘still unsettled’ is to be made, is the **here and now**; that is, the space-time point...” (Stein, 148)
- 2 There is a relation R ‘being real with respect to’. This relation Rxy is an **equivalence relation**, i.e. it is
 - 1 **reflexive**: $\forall x, Rxx$, a thing is real wrt itself
 - 2 **symmetrical**: $\forall x, y$, if Rxy , then Ryx
 - 3 **transitive**: $\forall x, y, z$, if Rxy and Ryz , then Rxz





Putnam concludes

"...that the problem of the reality and determinateness of future events is now solved. Moreover, it is solved by physics and not philosophy... Indeed, I do not believe that there are any longer any philosophical problems about Time; there is only the physical problem of determining the exact physical geometry of the four-dimensional continuum that we inhabit." (247, emphasis in original)

Why no form of presentism escapes the pressure

In a nutshell

*The basic problem for (almost) all forms of presentism is that it requires a metaphysically robust, objectively valid concept of a **spatially extended present**, and it seems that that can't be had.*

- A **spatially extended present** is the set of all spacetime points which are simultaneous with the **here-now**.
 - But the **relativity of simultaneity** in special relativity frustrates attempts of introducing an "objectively valid concept of a spatially extended present."
- ⇒ Hence I favour **eternalism**.

Forward and backward causation

- implicit assumption of all of the above: cause x temporally precedes effect y
- But is this necessarily so?
- Most have assumed that yes, but there a few dissenters.
- issue becomes relevant in
 - 1 question of whether time travel is possible
 - 2 interpretation of Bell's theorem in quantum mechanics

The Time Machine



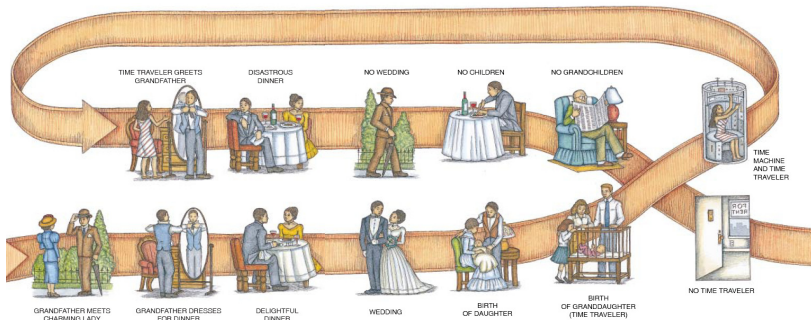
- H G Wells (1895), picture from 2002 movie 'The Time Machine'
- forward and backward travel in time
- forward time travel: twin paradox in special relativity

Time travel: the standard definition

Definition (Time travel (David Lewis))

“an object time travels iff the difference between its departure and arrival times in the surrounding world does not equal the duration of the journey undergone by the object” (Joel Hunter, “Time travel”, Internet Encyclopedia of Philosophy)

Grandfather paradox



Predestination paradox

- *Star Wars III: Revenge of the Sith*
- Anakin Skywalker has nightmares that his wife will die in giving childbirth
- in attempt to prevent this, he turns to the Dark Side for help
- this corrupts him and makes him assault her so that she 'loses her will to live' and dies shortly after giving childbirth
- Skywalker caused the very event he was trying to prevent **exactly by trying to prevent it**
- similar paradoxes in Shakespeare's *Macbeth*, *Star Trek*, *Harry Potter*, *The Terminator*...
- doesn't necessarily involve time travel

Ontological paradox: uncaused effects

Question: does the following constitute a violation of the principle of causality?

- Who wrote Shakespeare's plays?
- Time traveller discovers that neither Shakespeare, nor Marlowe, nor Bacon, nor any other of the usual suspects has...
- So he travels back in time to bring his *Complete Works* to Shakespeare together with a timeline.
- Shakespeare then copies and publishes the plays according to the timeline...

After Jasper Fforde, *The Eyre Affair*, 2001.

Resolving the ontological (and predestination) paradox



David Lewis, 'The paradoxes of time travel', *American Philosophical Quarterly* 13 (1976): 145-152.)

- problem with ontological paradox: unexplained and uncaused effects
- Lewis (1976): \exists many unexplained, uncaused events: existence of God, big bang, decay of tritium atom
- fact that ontological paradoxes contravene our causal intuitions not in itself an argument against possibility of these stories
- moreover: is the principle of causality really violated?
- Should there be a distinction between 'local' and 'global' causation?
- similarly with predestination paradoxes: undoubtedly irony in these stories, but they don't threaten consistency

Resolving the grandfather

There's an obvious inconsistency here, so more work will be required...

Resolutions:

- reject classical logic in favour of logic which permits contradictions (*dialethic logic*)
- Jack Meiland's two-dim model of TT
- multiverses and similar modal constructs
- consistency constrains such as Ivan Novikov's self-consistency principle

Meiland's two-dimensional model



Jack W Meiland, 'A two-dimensional passage model of time for time travel', *Philosophical Studies* **26** (1974): 153-173.

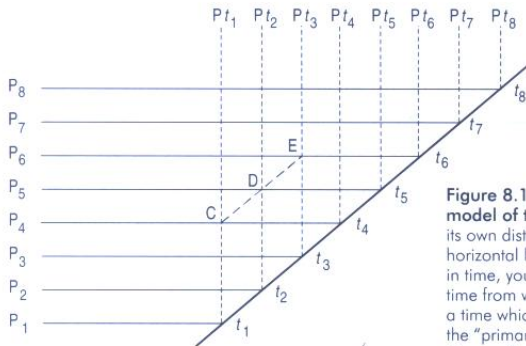
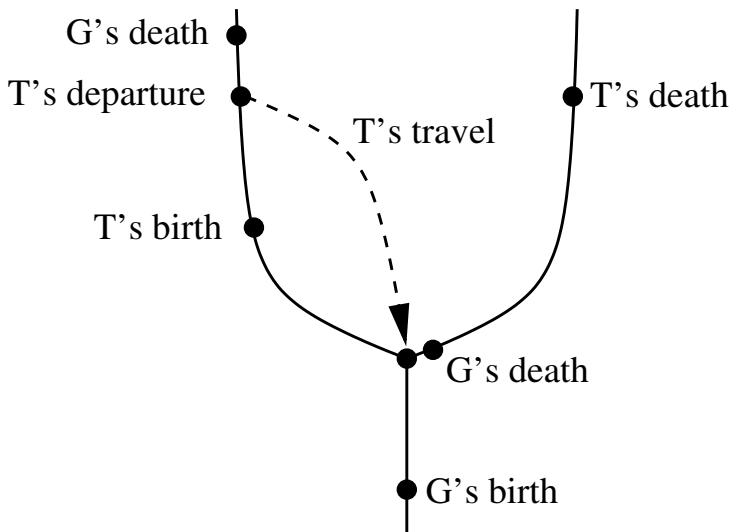


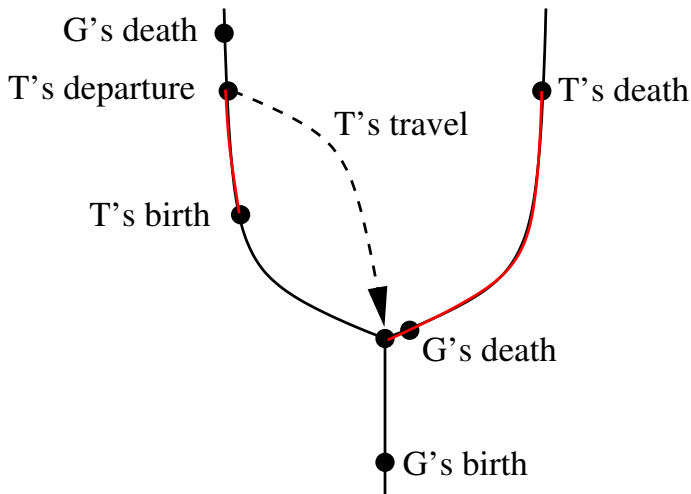
Figure 8.1 Meiland's two-dimensional model of time travel. Each moment has its own distinct past, indicated by the horizontal lines. If you were to travel back in time, you would arrive in the past of the time from which you departed, rather than a time which preceded your departure on the "primary" timeline (indicated by the diagonal).

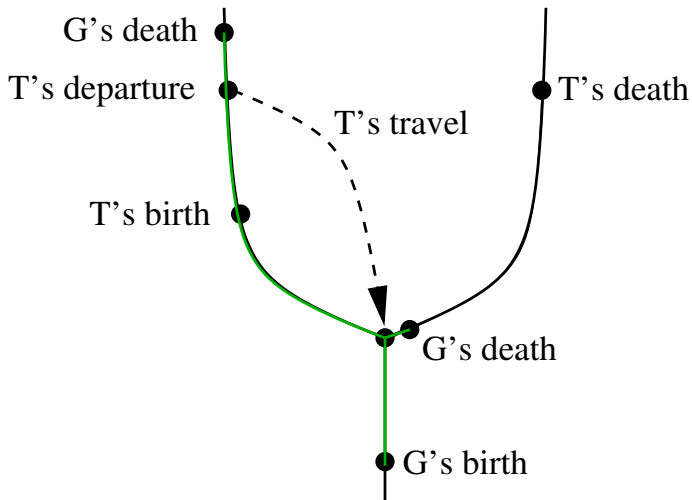
- the past changes in the sense that it is not cumulative

The multiverse proposal



Important: if everybody's worldlines have beginning and end points in all branches, the grandfather paradox cannot arise (and similar paradoxes mutatis mutandis).





Consistency constraints



John Earman, *Bangs, Crunches, Whimpers, and Shrieks*, Oxford University Press, 1995.

- Earman (1995): grandfather paradox nothing but crude way of saying that \exists consistency constraints (CCs) in order to ensure absence of contradictions
- CCs thus imply that a time-travelling murderer **must** fail to kill Grandpa in the intended way

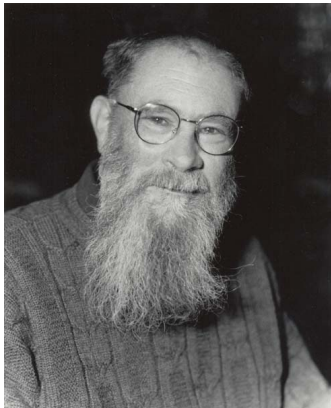
Principle (Novikov's self-consistency principle)

If an event's existence would engender an inconsistency, such as a change of the past, then the probability that this event occurs is zero.

Problems:

- counterfactual formulation
- better formulated in terms of inconsistent sets of events
- probabilistic formulation means that event can still occur...

Lewis's modal inconsistency



- CCs entail that past cannot be changed; so if John Connor's mother survives 1984, she does so tenselessly
- Modal paradox: Terminator can and cannot kill Sarah Connor before she gives birth to John
- Lewis (1976): invalid equivocation of 'can'
- 'can' is always relative to a set of facts (compossibility): assuming that this and that is the case, this or that can or cannot be done
- paradox resolved

Conclusions so far

- 1 Logic itself does not prohibit time travel, it just constrains the sort of scenarios that can occur.

Metaphysical concerns

- now common view among philosophers: so a time traveller cannot **change** the past, but she must still **affect** it
- Causal relation bw antecedent conditions prior to departure and consequent conditions upon (the earlier) arrival ascertain personal persistence of time traveller and thus necessary identity conditions.
- But if this relation is causal, it seems as if there must be **backward causation**, i.e. causal relations where the effect precedes the cause.

The metaphysical master argument

The metaphysical master argument against the possibility of time travel:

- 1 Time travel necessarily involves backward causation.
 - 2 Backward causation is (conceptually) impossible.
- ∴ Time travel is (conceptually) impossible.

Note: it may be that the first premise needs to be qualified or even rejected, but metaphysicians are usually interested in the second, so let's look at that.

The bilking argument against backward causation



Max Black, 'Why cannot an effect precede its cause?', *Analysis* **16** (1956): 49-58.



Michael Dummett, 'Bringing about the past', *Philosophical Review* **73** (1964): 338-359.

- General idea of bilking argument: set up an experiment s.t. whenever we observe the absence (presence) of an earlier potential effect e , we try to produce (prevent) the subsequent occurrence of the potential cause c
- Repeat the experiment many times, get statistics and find that either
 - (i) e often occurs despite the absence of c and that e was often absent when we produced c ; or
 - (ii) our attempts to produce c consistently fail if e didn't occur, and whenever e occurs, we cannot prevent the occurrence of c .

- Example: dancing chief (Dummett 1964)
- in case (ii) (bilking fails) our ability to produce c depends on the previous presence or absence of $e \Rightarrow$ thus it seems as if e is a necessary causal antecedent condition for c and should thus be considered its cause rather than its effect
- in case (i) (bilking successful) our hypothesis of backward causation is simply false, as there seems to be no causal relation between c and e
- Many have concluded that this argument shows that in cases where experimental design can be implemented, there cannot exist backward causation.

Problem with bilking argument

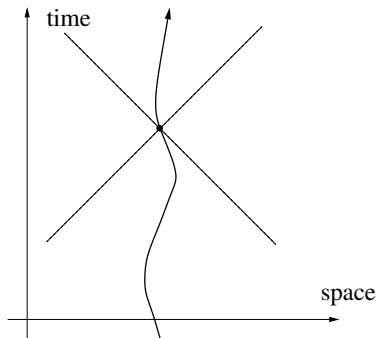
- 1 If conditions for experimental design are not satisfied: you cannot discover whether an alleged earlier effect has in fact occurred
 - because it is nomologically impossible to do so
 - or it is possible to discover this, but only at the price of disrupting the system in a way that is itself causally relevant for occurrence of e (e.g. in quantum mechanics)
- 2 Even if experimental design can be implemented, the arg may not be successful: we may fail to bilk not bc there's a (reversed) causal relation between e and c , but simply bc of "strangely *convenient* coincidences" (Dainton, 122)
 - these coincidences may be due to global 'consistency constraints'
- **In conclusion**, not clear how successful bilking arg really is against the possibility of backward causation.

Conclusions so far

- 1 Logic itself does not prohibit time travel, it just constrains the sort of scenarios that can occur.
- 2 Metaphysical (and other philosophical) arguments against time travel are far from conclusive, particularly bc time travel need not involve backward causation...

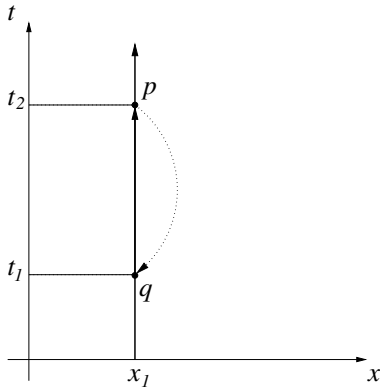
Does physics permit time travel?

Cast problem in spacetime language:



- simplification for one spatial and one temporal dimension
- **convention**: propagation of light drawn as bisecting line
- Light postulate in special relativity (SR): nothing ever travels faster than light
- Does casting issue in 4d prejudice debate between dynamist and staticist? Yes, but remember that all of this is in defence of staticist.

Wellsian time travel four-dimensionally



- event p : switch lever, press button
- event q : arrival in our past

Discontinuities? Not necessarily.
Backward causation? You bet!

Backward causation is unphysical!

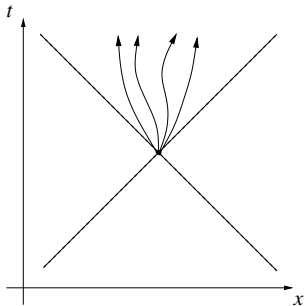


Figure: Forward causation

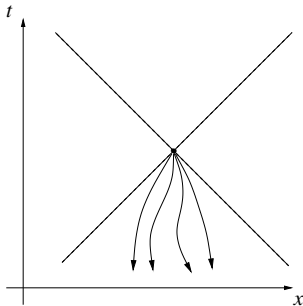


Figure: Backward causation

P.S. According to SR, signals which leave the point of origin “sideways” are also prohibited.

Time travel in Einstein's general relativity (GR)

Core of GR: **Einstein equations** (or Einstein field eqs)

$$G_{\mu\nu}[g_{\mu\nu}] = 8\pi T_{\mu\nu}$$

$G_{\mu\nu}[g_{\mu\nu}]$: functional of the metric $g_{\mu\nu}$ and its first and second partial derivatives; **contains complete information about the geometrical structure of spacetime.**

$T_{\mu\nu}$: energy-mass-density; **describes the distribution of (energy and) masses in the spacetime.**

In Einstein's GR, gravity is interpreted as **curvature of spacetime**:

Spacetime geometry \iff distribution of matter and energy

Consequence: one can go 'straight' in a curved spacetime and yet return to the same point. (Analogy: globe)

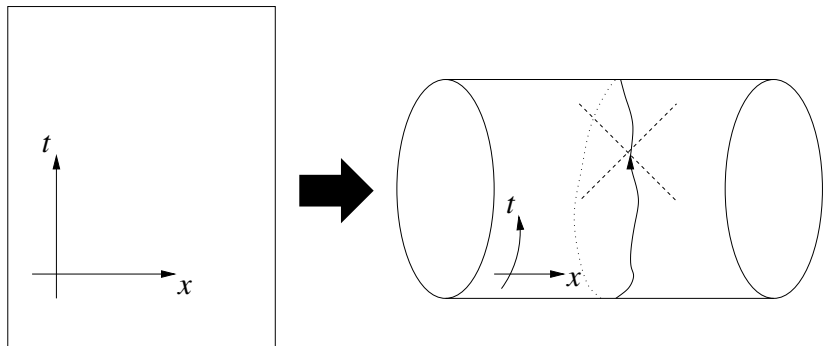
Kurt Gödel 1949: solution of Einstein equations with **closed causal curves** (CCCs), the so-called **Gödel spacetime**

Closed causal curves

- **closed**: curve intersects itself
- **causal**: without backward causation, just 'forward causation' of signals, not faster than speed of light
- But how can curve be closed and causal at the same time??
- Answer: by taking advantage of geometrical structure of spacetime, i.e. of **curvature**

Examples of spacetimes with closed causal curves

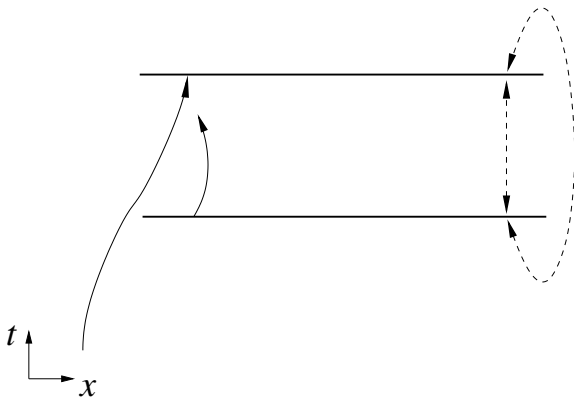
Basic idea:

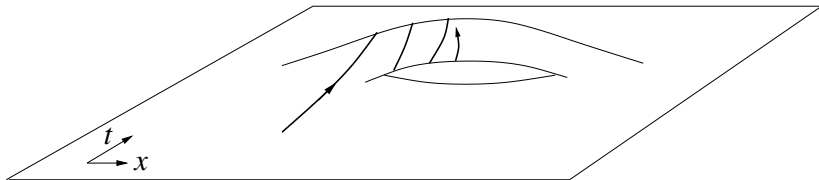


Deutsch-Politzer-spacetime: 'regional' acausalities

'Global' acausalities, i.e. occurrence of CCCs;

It is also possible that CCCs are confined to region:





Deutsch-Politzer spacetime has a local 'handle'; CCCs are confined to this region.

Conclusions

- 1 Logic itself does not prohibit time travel, it just constrains the sort of scenarios that can occur.
- 2 Metaphysical (and other philosophical) arguments against time travel are far from conclusive, particularly bc time travel need not involve backward causation...
- 3 So to the best of our knowledge, time travel is neither metaphysically nor physically (or nomologically) impossible; it does or could occur in our world.