Time Travel and Parallel Universes

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Science Café
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Outline

Time Travel in Science Fiction

- *The Time Machine*, H. G. Wells, 1895 is probably the first novel in which an instrument of time travel was described. But the notion of time travel appeared in many earlier stories.
- Time travel is a very popular theme in modern day science fiction genre.
- Some examples of tv shows and movies where the notion of time travel appeared include: Back to the Future (film), Battlestar Galactica (tv), Butterfly Effect (film), the Caller (film), Continuum (tv), Doctor Who (tv), Eureka (tv), Frequency (film), Fringe (tv), Star Treck franchise (tv, film), Stargate Atlantis (tv), Stargate SG-1 (tv), Tera Nova (tv), Terminator (film, tv), X-Files (tv), etc.

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Time Travel in Science Fiction
Continued

- The most intriguing idea in time travel stories is that one travels back in time and alter the future. Is that really possible?

What Do Physicists Say About Time Travel?

- There is no consensus among physicists on whether time travel is possible.
- But they mostly agree that traveling back in time is impossible. There is no technical reason for this belief but it is mainly due to a paradox called *grandfather paradox*.
- On the other hand, Einstein's theory of special relativity allows us to travel forward in time. But it is a *boring* time travel.

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Three Relativistic Effects

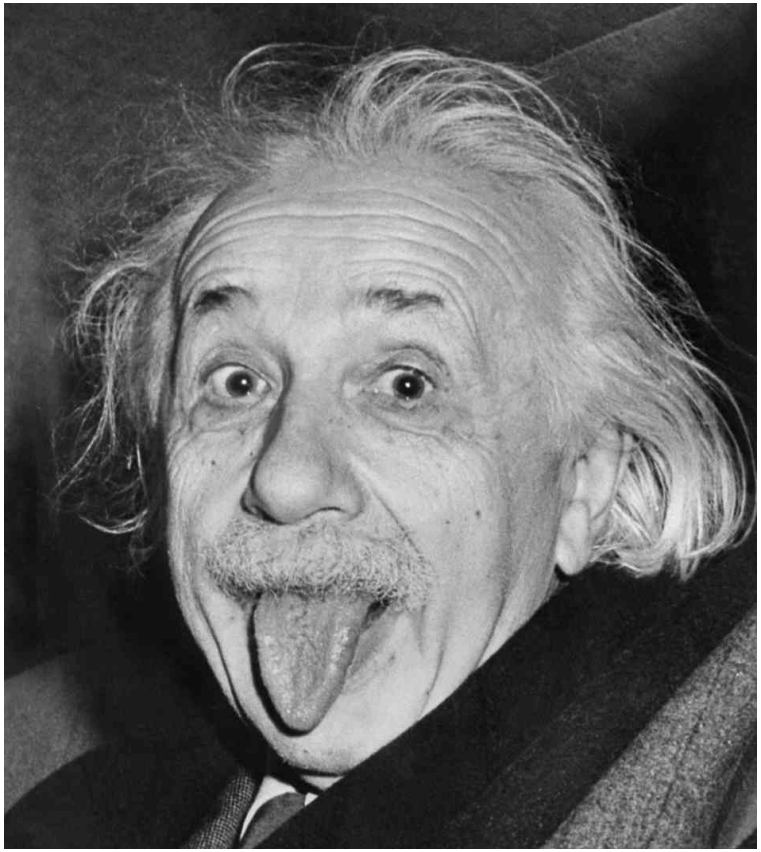

Figure : Albert Einstein (1879 - 1955)

Three Relativistic Effects
Continued

Imagine that you are traveling in a spaceship. According to the theory of relativity, you will experience the following three effects as you accelerate.

- *Time Delay*

$$\triangle t' = \frac{\triangle t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

- *Contraction of Length*

$$\ell = \ell_0 \sqrt{1 - \frac{v^2}{c^2}}$$

- *Increase of Mass*

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

A Rebelion: Gödel Universe

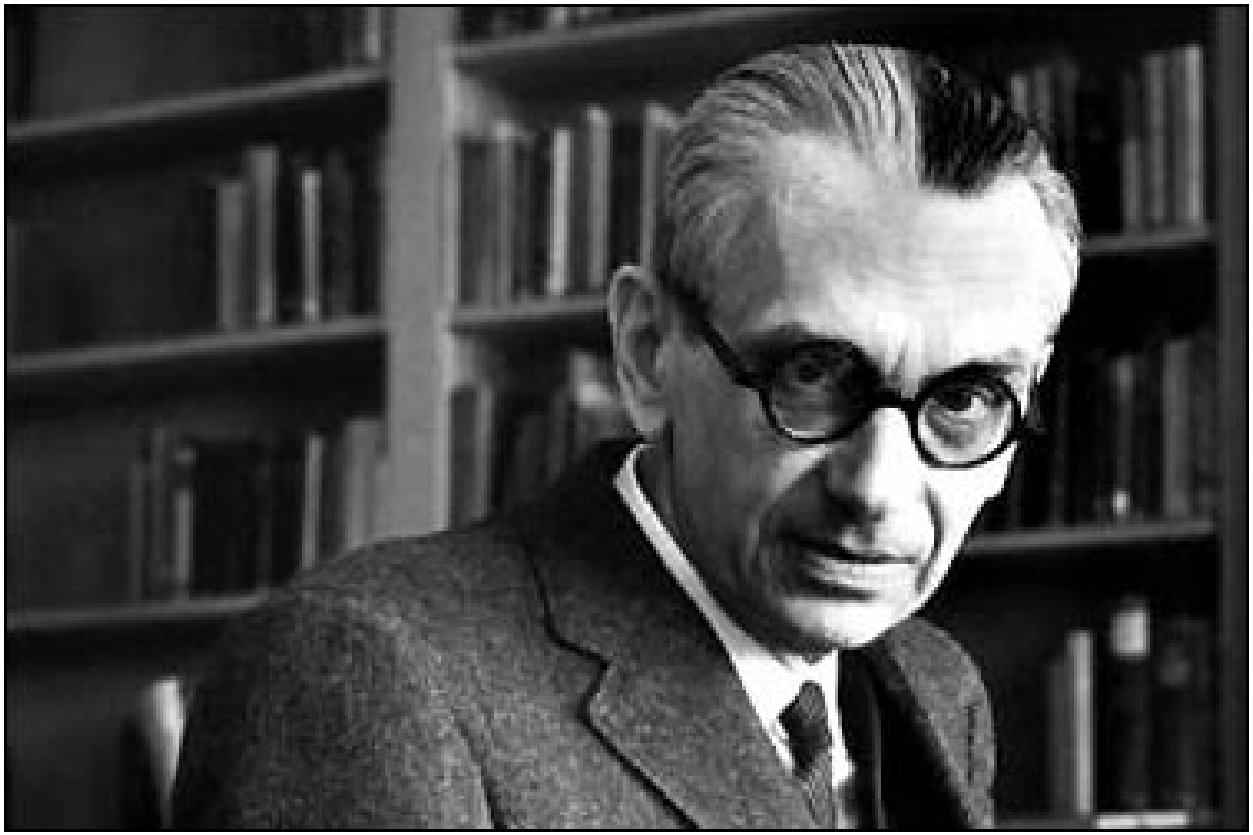

Figure : Kurt Gödel (1906 - 1978)

A Rebelion: Gödel Universe
Continued

Inspired by Einstein's theory of general relativity, Kurt Gödel considered a model of universe that contains closed timelike curves, so his model allows backward time travel. Gödel also believed that one may travel back in time, influence past events and alter the future as a consequence. While Gödel universe is a solution of Einstein's field equations, most physicists consider the model as unphysical.

Time Machine

- It appears that the only thing that prevents us from traveling back in time is grandfather paradox or its variants. For now, let us forget about grandfather paradox. Is it then even remotely possible to build a time machine?
- The answer is affirmative and the name of our time machine is *wormhole*. So what is a wormhole?

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- The answer is affirmative and the name of our time machine is *wormhole*. So what is a wormhole?

Wormholes

- When a massive star dies, it collapses due to the influence of its own gravity. This phenomenon is called *gravitational collapse*.
- If the star is very massive, the gravitational collapse leads to a singularity in space-time called, *black hole*.
- Since the space-time has no edges, the trajectories of particles fell into the event horizon of a black hole must be continued unless a particle hits the black hole singularity. This requirement hints us the existence of a *white hole*.
- A black hole is connected to a white hole, its counterpart through a tubelike region called a *Lorentzian wormhole* (also called a *Schwarzchild wormhole* or *Einstein-Rosen bridge*).
- Black holes, white holes, and wormholes are all solutions of Einstein's field equations.

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Wormholes
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- We do not know yet what happens inside a black hole, or how physically white holes and wormholes are created.

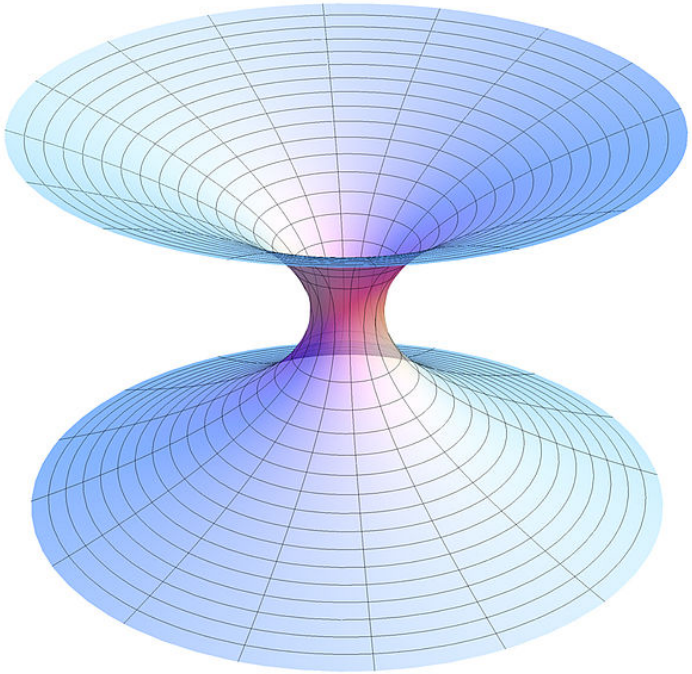

Figure : A Lorentzian wormhole

A Wormhole as a Time Machine

- When a black hole is created, its massive gravitational field bends not only space but also time according to the theory of general relativity.
- Time can be bent in either future or past direction. However, due to *causality* it can be bent only in past direction. (My own speculation.)
- I speculate that warping space and time results fluctuations in the space-time and when two local regions (present and past) of the space-time get close enough, there can be an attractive force (*Casimir effect*) between the two regions causing the creation of a wormhole connecting to a white hole at an event in the past.

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Causality

- Every *effect* is followed by a *cause*. This is called *causality* in physics.
- Due to causality, we cannot travel forward in time through a wormhole because for us the future does not exist yet.
- But the creation of a white hole at an event in the past also violates causality since the white hole did not exist at that event in the past. How do we cope with the change of history?

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Chronology Protection Conjecture

Regaring time travel there are currently four different conjetures.

- *The radical rewrite conjecture*: One can travel forward and back in time and rewrite the history. (All Hell breaks loose.)
- *Novikov's consistency conjecture*: The Universe is consistent, so whatever temporal transpositions and trips one undertakes, events must conspire in such a way that the overall result is consistent.
- *Hawking's chronology protection conjecture*: The cosmos works in such a way that time travel is completely and utterly forbidden. This conjecture permits spacewarps/wormholes but forbids timewarps/time machines.
- *The boring physics conjecture*: There are no wormholes and/or spacewarps. There are no time machines/timewarps.

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Protect History!

I am personally fond of Novikov's consistency conjecture. In fact, I require a stronger version of Novikov's consistency conjecture which does permit timewarps/time machines but not permit any violation causality and any tampering with already recorded history. I speculate that:

- as soon as any tampering with recorded history occurs such as the appearance of a white hole at some time and place in the past caused by a timewarp from the future, a new time line has to be created in order to prevent history from being rewritten.
- as a consequence, a new reality is created from that moment completely separated from the previously existing reality.
- This new reality may turn out to be pretty much similar to the previous reality, or it may turn out to be very different.

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Parallel Universes and Many-Time Physics

- The creation of new realities results an emergence of new physics, *many-time physics*.
- If there are many different realities (parallel universes), the theory of physics should be built on the geometry of $\mathbb{R}^{3+q}$ where q is the time dimension.
- The new theory must be consistent with the current theory of physics on each reality.
- Big Questions:
  1. Can different realities interact with each other?
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Tachyons

- *Tachyons* are hypothetical FTL (Faster Than Light) particles.
- Tachyons were introduced by Gerald Feinberg in 1967 as particles with imaginary rest mass. It turned out that such particles do not propagate faster than light.
- If tachyons as FTL particles exist, they travel back in time.
- Tachyons may be produced as a byproduct when a new reality is created because of a violation of causality.
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Déjà Vu and Premonition: Messages from an Alternate Reality?

If you have a déjà vu or a premonition, you may not want to ignore it. It could be a message from the future (of a different reality) carried by tachyons.

Suggested Reading

1. *Black Holes and Time Warps: Einstein's Outrageous Legacy*, Kip S. Thorne and Stephen Hawking (Foreword), W. W. Norton & Company, 1995 (for laypeople)
2. *Lorentzian Wormholes: From Einstein to Hawking*, Matt Visser, AIP Series in Computational and Applied Mathematical Physics, 2008 (for people with a substantial background in mathematics and physics)

Questions?

Thank you!