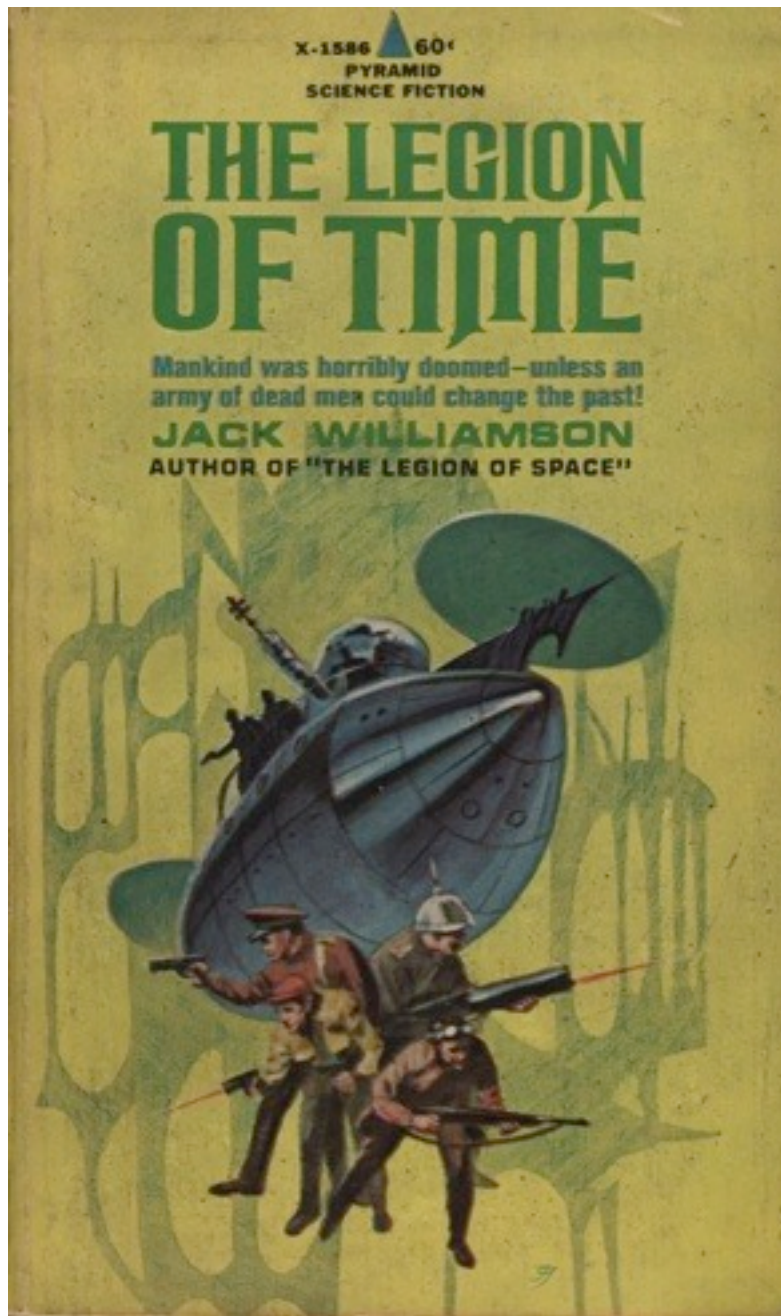


The Physics of Time Travel

John Ashmead

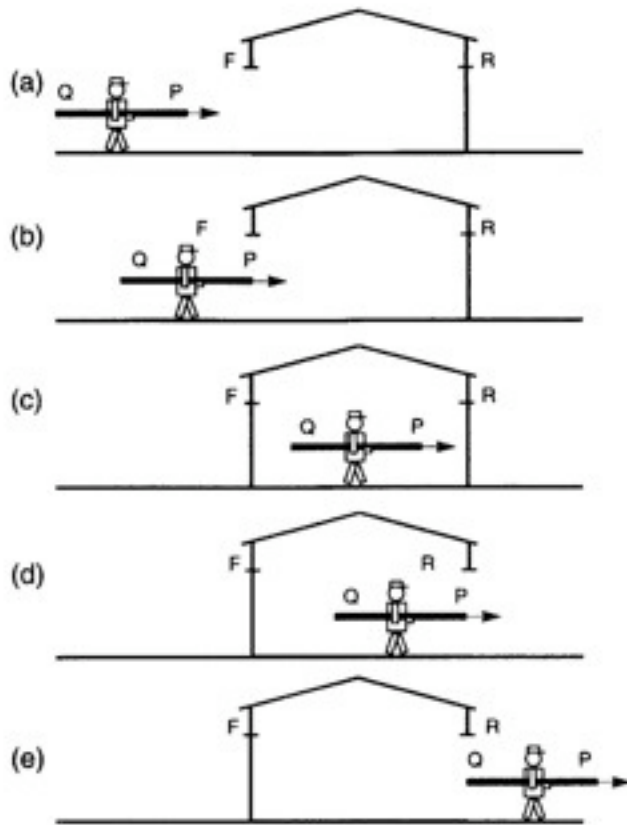
- “Really this is what is meant by the Fourth Dimension, though some people who talk about the Fourth Dimension do not know they mean it. It is only another way of looking at Time. There is no difference between time and any of the three dimensions of space except that our consciousness moves along it.” - The Time Traveler

john.ashmead@timeandquantummechanics.com



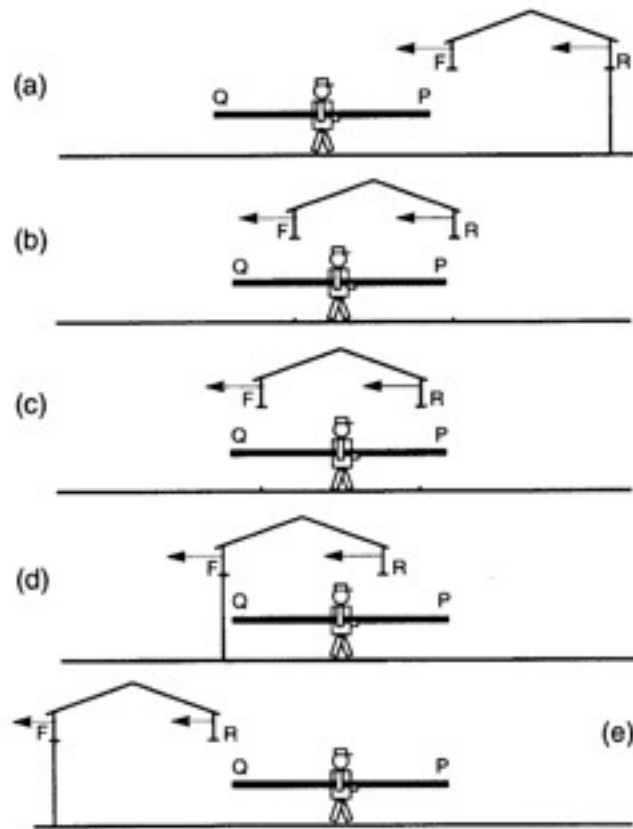
- What is time?
- Is time travel possible?

Time is Weird (1)



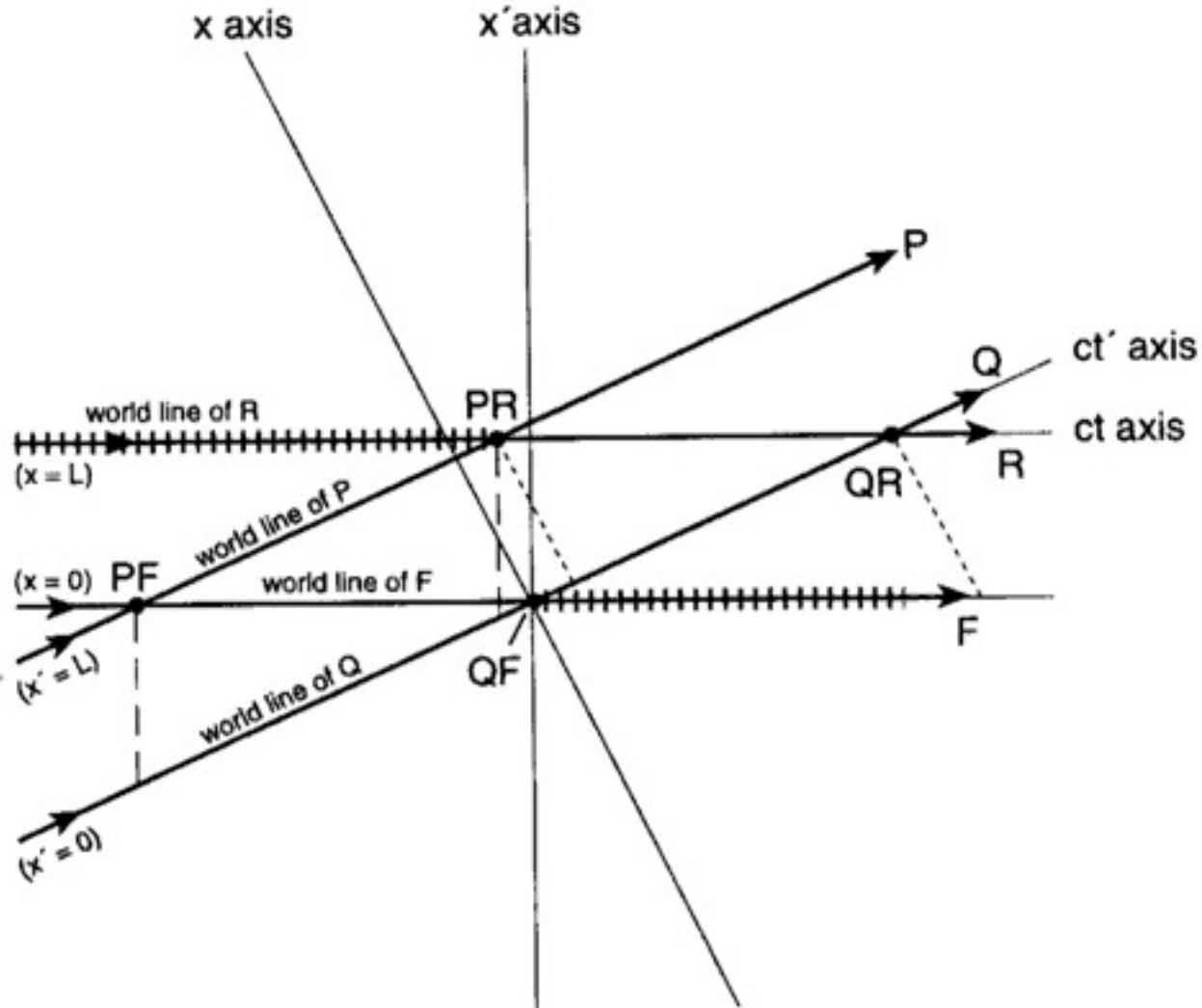
- Pole moving
- House at rest
- Pole is shortened, so fits in the house
- (per Sartori)

Time is Weird (2)



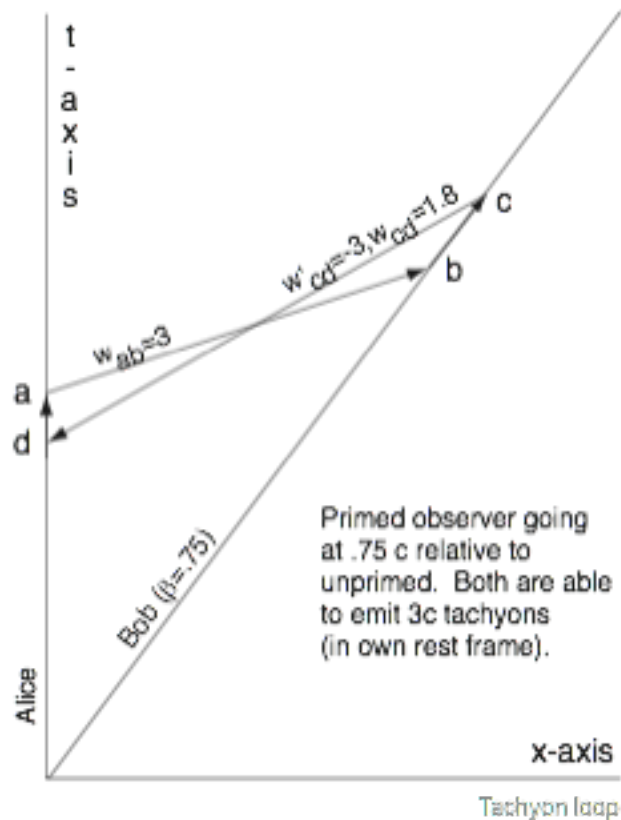
- Pole at rest
- House moving
- House is shortened
- But “fortunately” both doors are open at the same time!

Time is Weird (3)



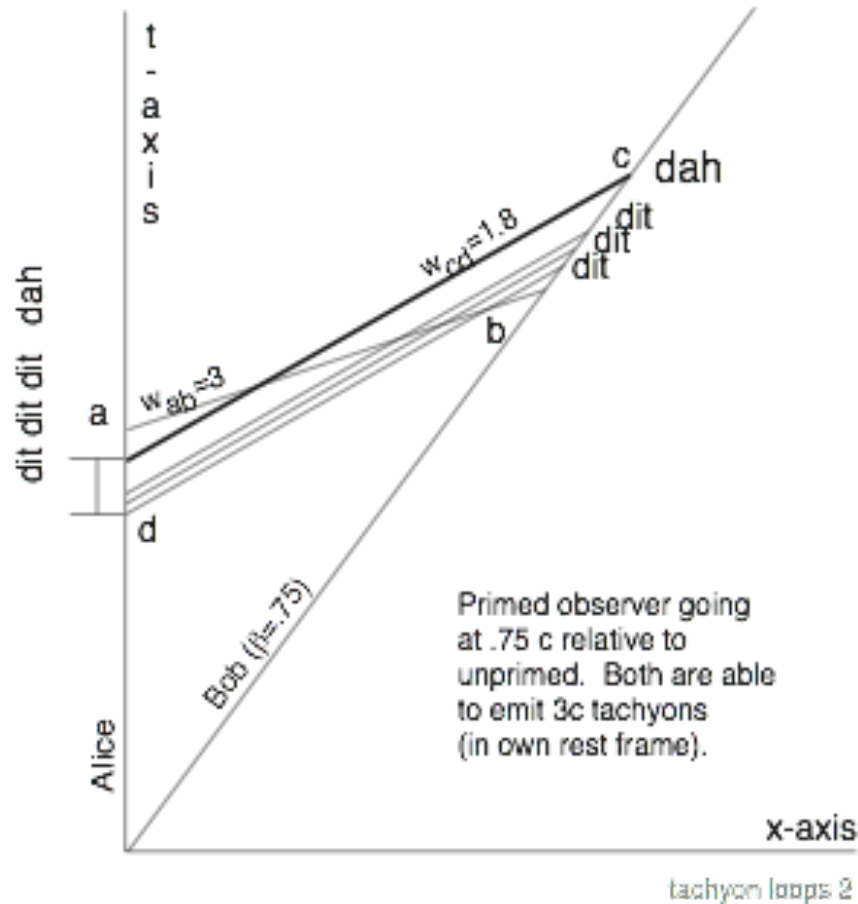
- Pole & house together on one space-time diagram.

Tachyon loops (plain)



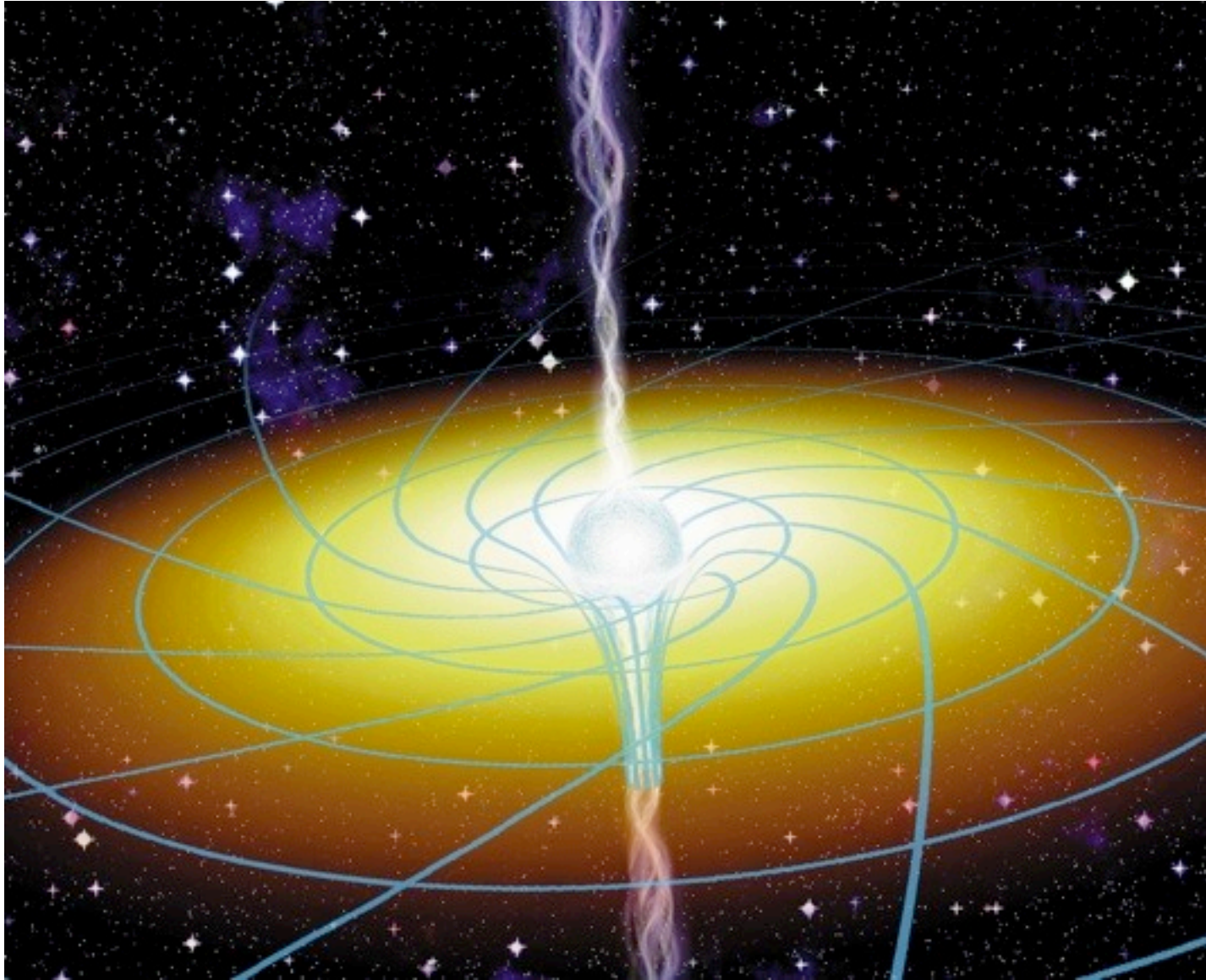
- In the diagram (drawn to scale) Alice sends a message at **a** which gets to Bob at **b**. Bob processes the message then at **c** sends Alice a reply which she receives at **d**, *before* she sent the first message.

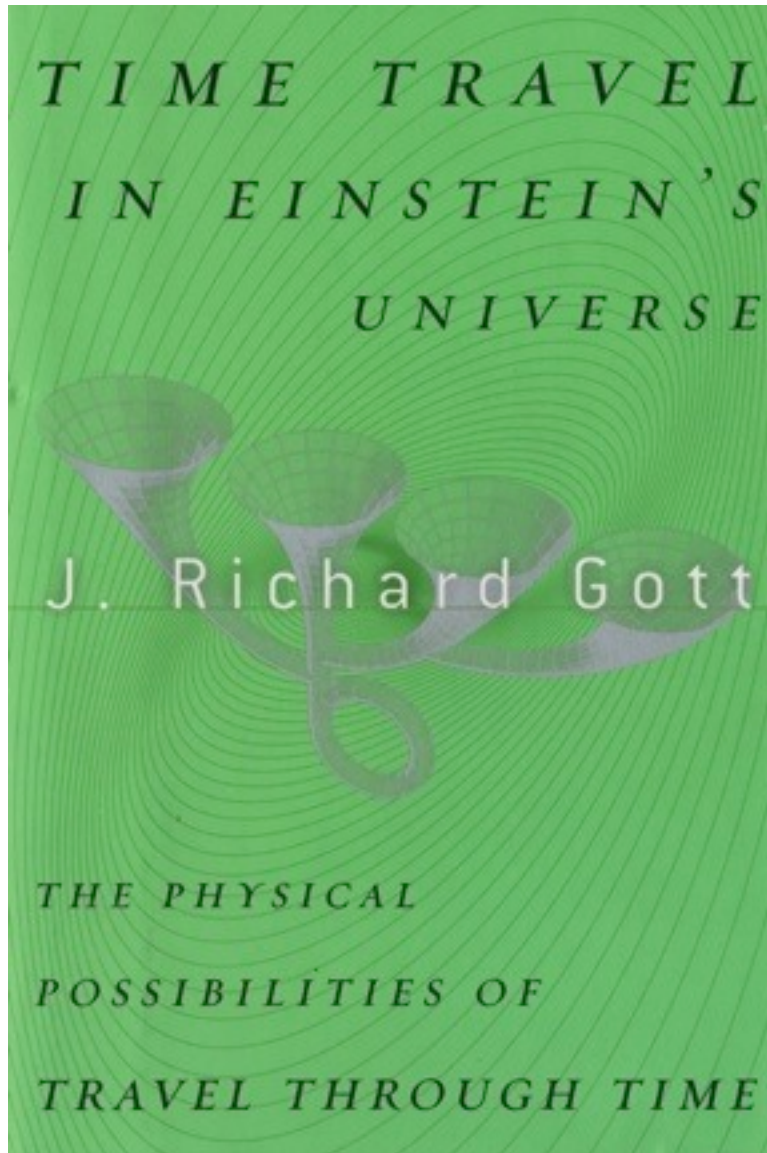
Tachyon loops (musical)



- Bob might choose to send Alice the first few notes of Beethoven's Fifth symphony...

Frame-dragging

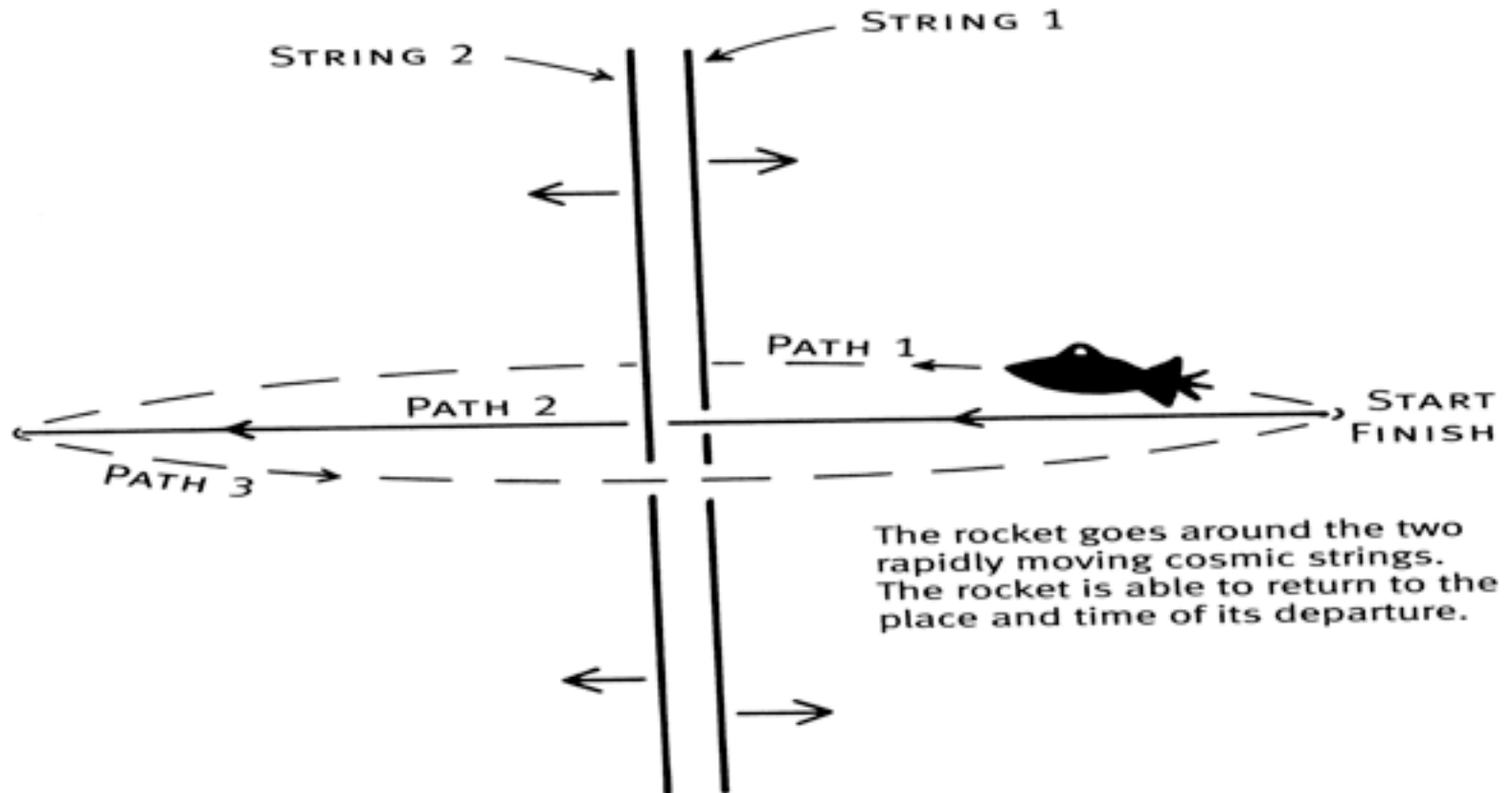


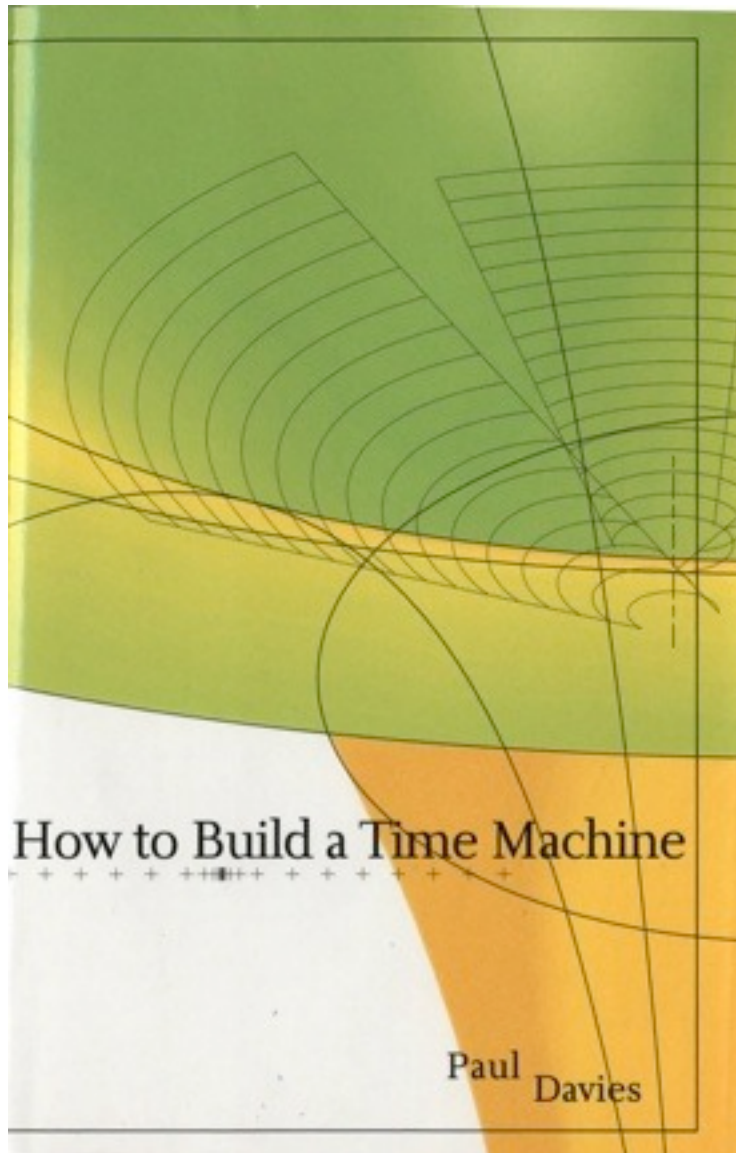


- One of the CTC inventors
- And also of a way of estimating time ranges from very small samples

Two string time machine

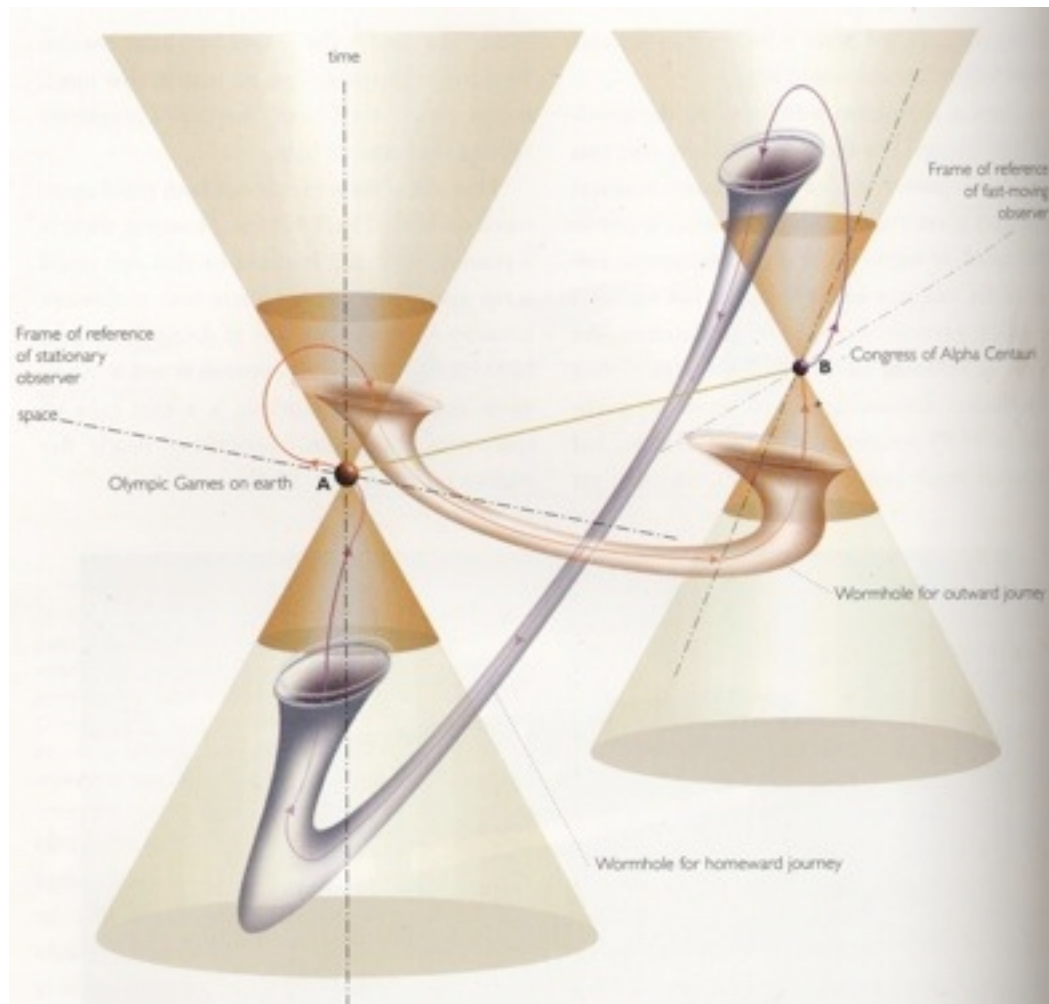
By Gott



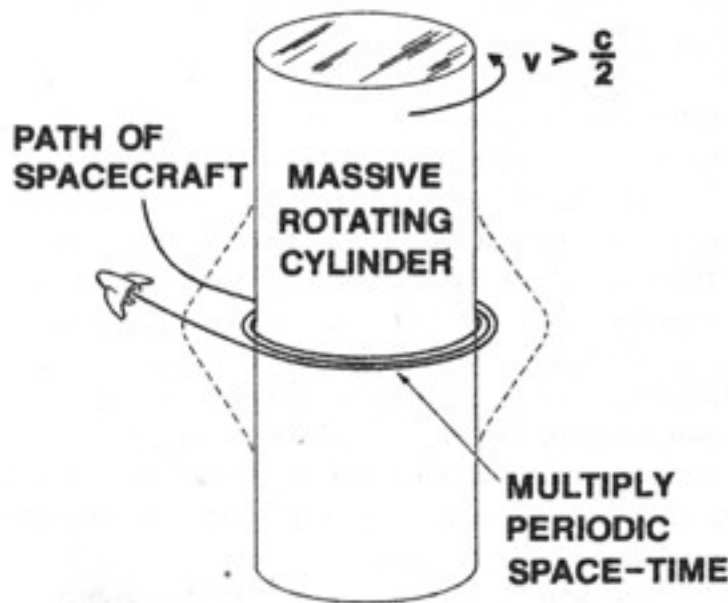


- Wormholes, Tachyons, & Time Travel, Oh My
- Excellent introduction to the physics
- And short!
- With a first rate bibliography (he has taken time to write a short one)

Wormholes to go back in time

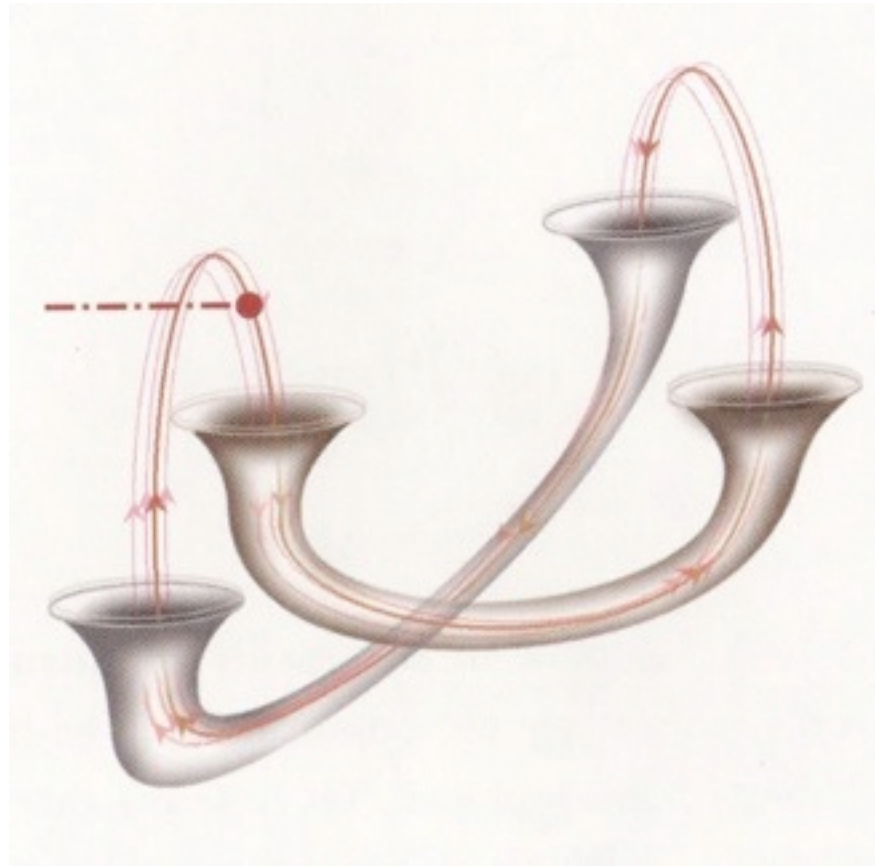


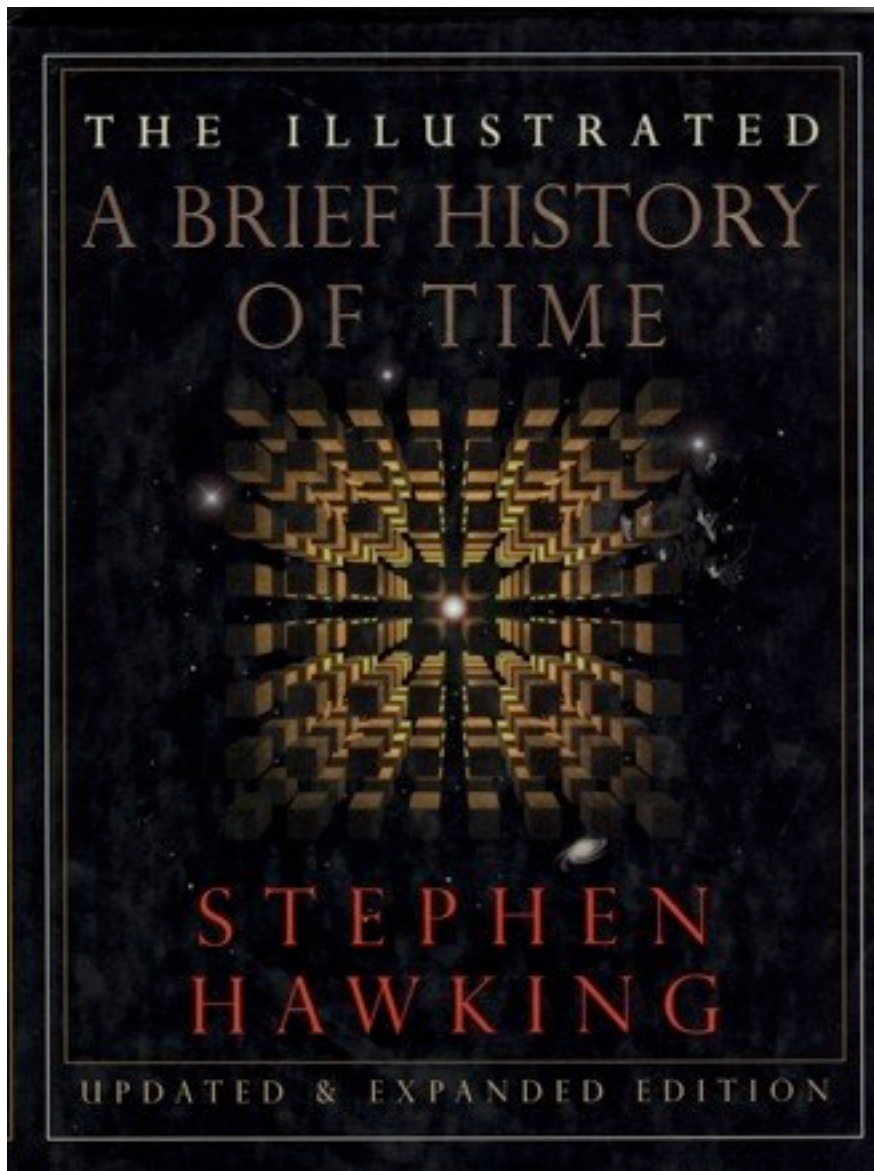
On Rotating Cylinders & the Possibility of Global Causality Violation



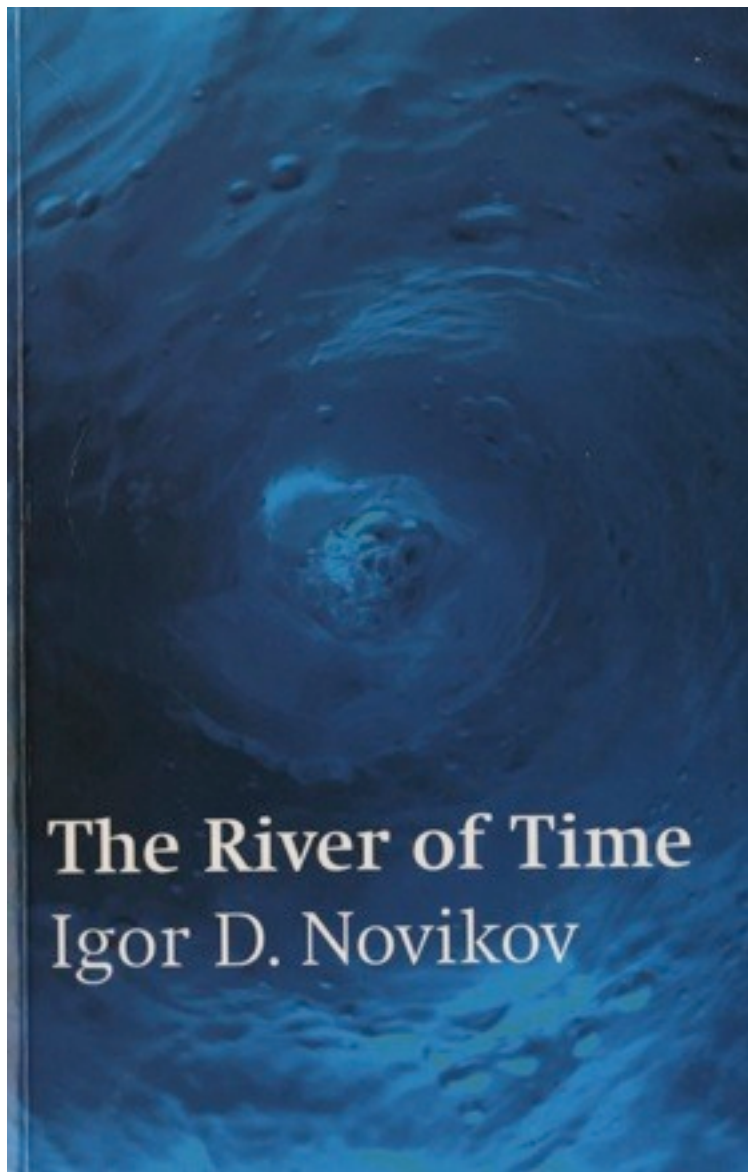
- Niven's Law:
- “If the universe of discourse permits the possibility of time travel, and of changing the past, then no time machine will be invented in that universe.”

Positive Feedback in Time





- Chronology protection conjecture:
- “The laws of physics do not allow the appearance of closed timelike curves.”
- “Thus the possibility of time travel remains open. But I’m not going to bet on it. My opponent might have the unfair advantage of knowing the future.”



- Novikov has taken a stronger position, in his Novikov consistency conjecture : inconsistent trajectories are forbidden: self-consistency is treated essentially as one of the boundary conditions imposed on any problem.

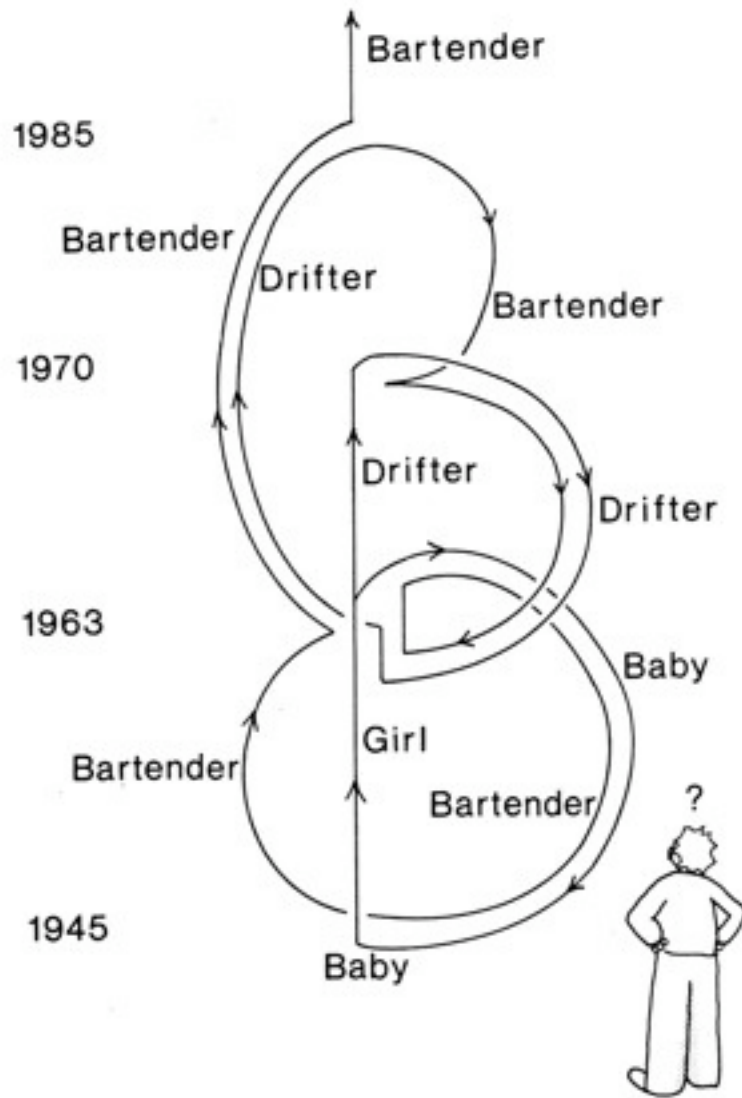
Visser's Four Possibilities

- Radical rewrite
- Novikov consistency conjecture
- Hawking's Chronology Protection Conjecture
- Boring Physics Conjecture

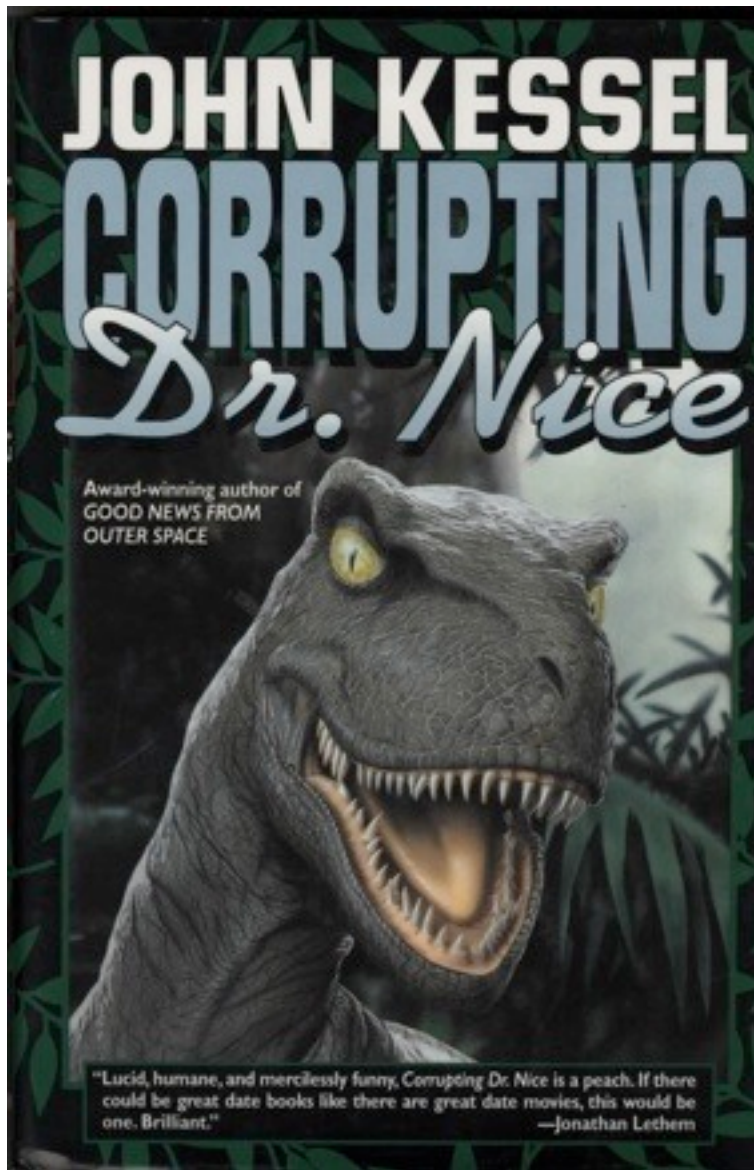
Three Paradoxes

- Consistency paradoxes
 - *Killed own grandpa?*
- Bootstrap paradoxes
 - *Where did the book come from?*
- Plausibility paradoxes
 - *No human acts like that!*

All You Zombies



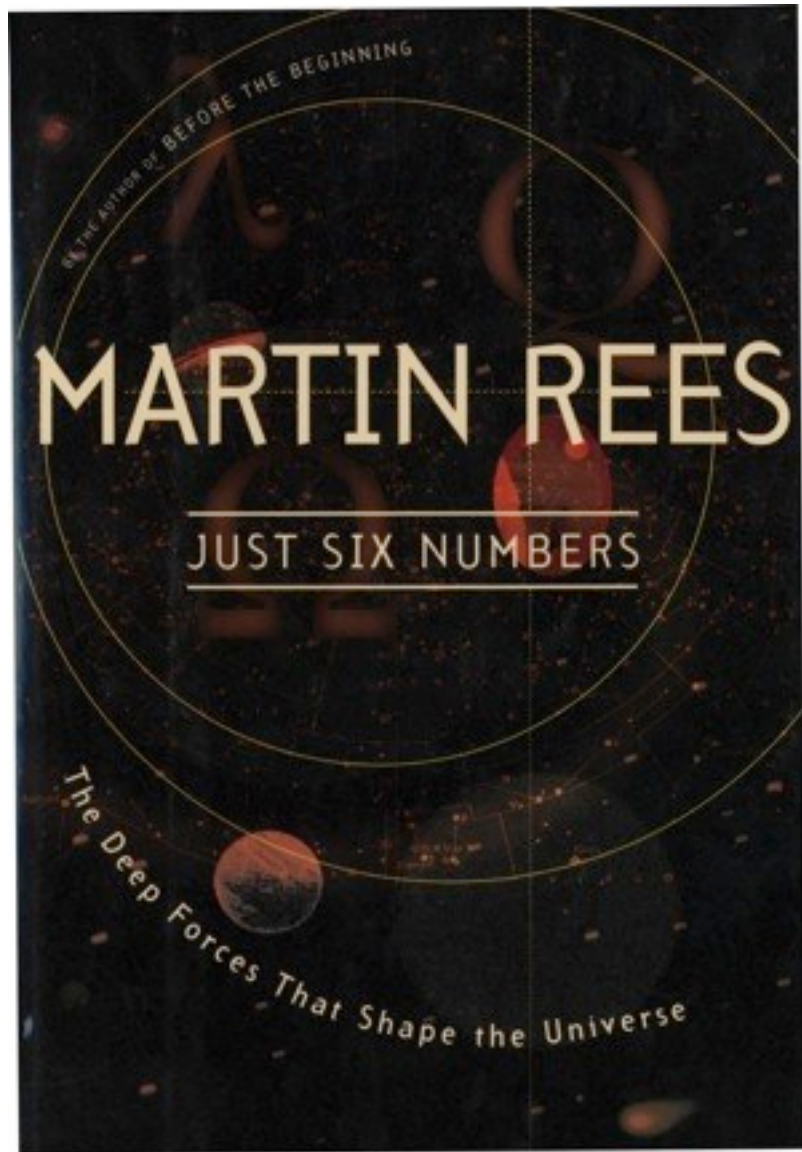
- A Paradox can be paradoctored!
- “I’m My Own Grandpa”
- “I know where I come from, but where do all you zombies come from?”
- (Drawing is from Kaku’s Hyperspace)



- “If you want to see what would happen if you turned a machine gun on Brutus and the conspirators, we can arrange that--but not on this tour! We don’t want to have too much fun, do we?”

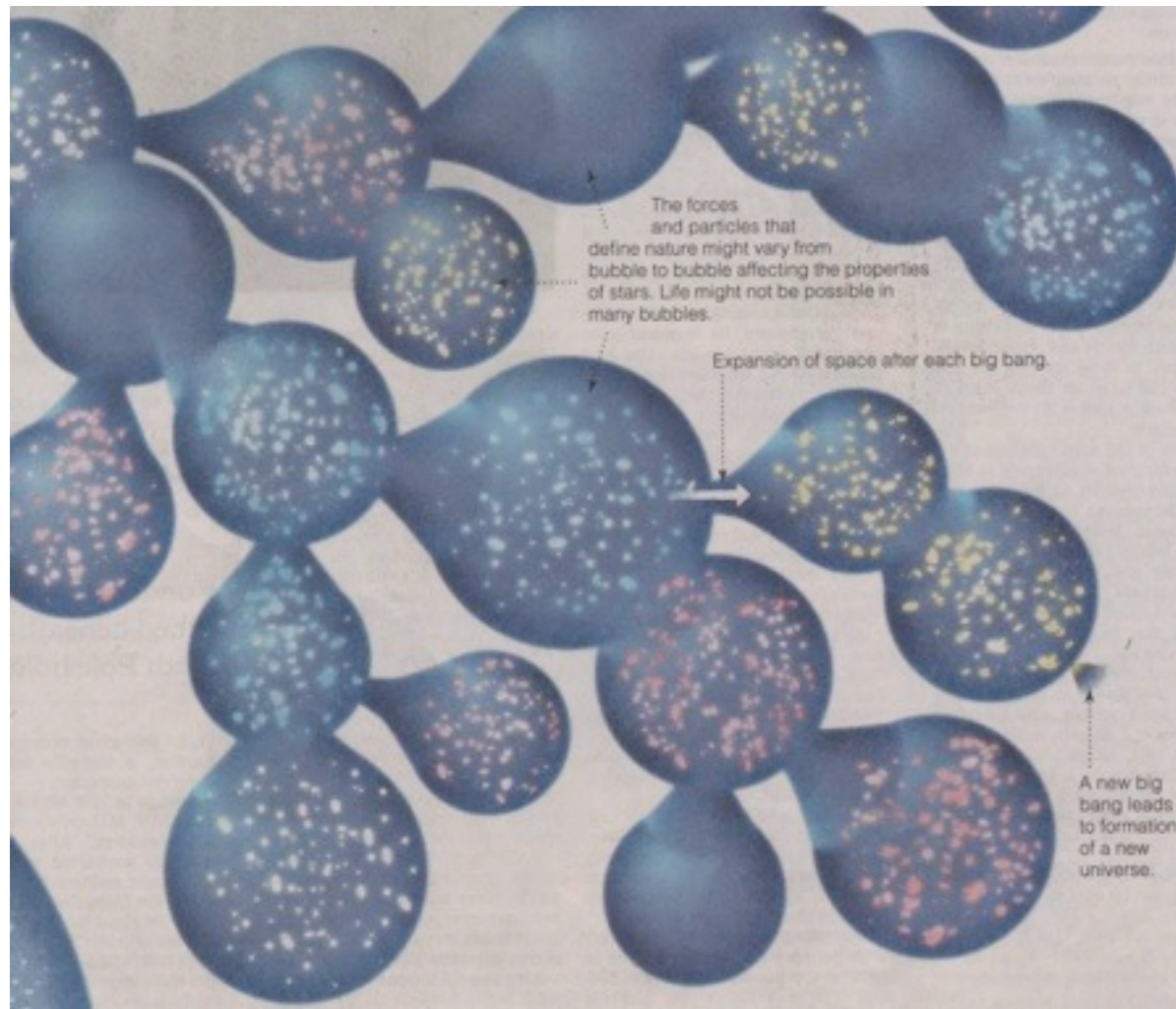
The Anthropic Cosmological Principle

- “intelligent life...selects out the actual Universe from among the different imaginable universes: the only “real” universes are those which can contain intelligent life...”



- The large number N : gravity in the cosmos
- The stars, the periodic table, and ϵ .
- The fine-tuned expansion: dark matter and Ω .
- The number λ : is cosmic expansion slowing or speeding?
- Primordial ripples: the number Q
- Three dimensions (& more)

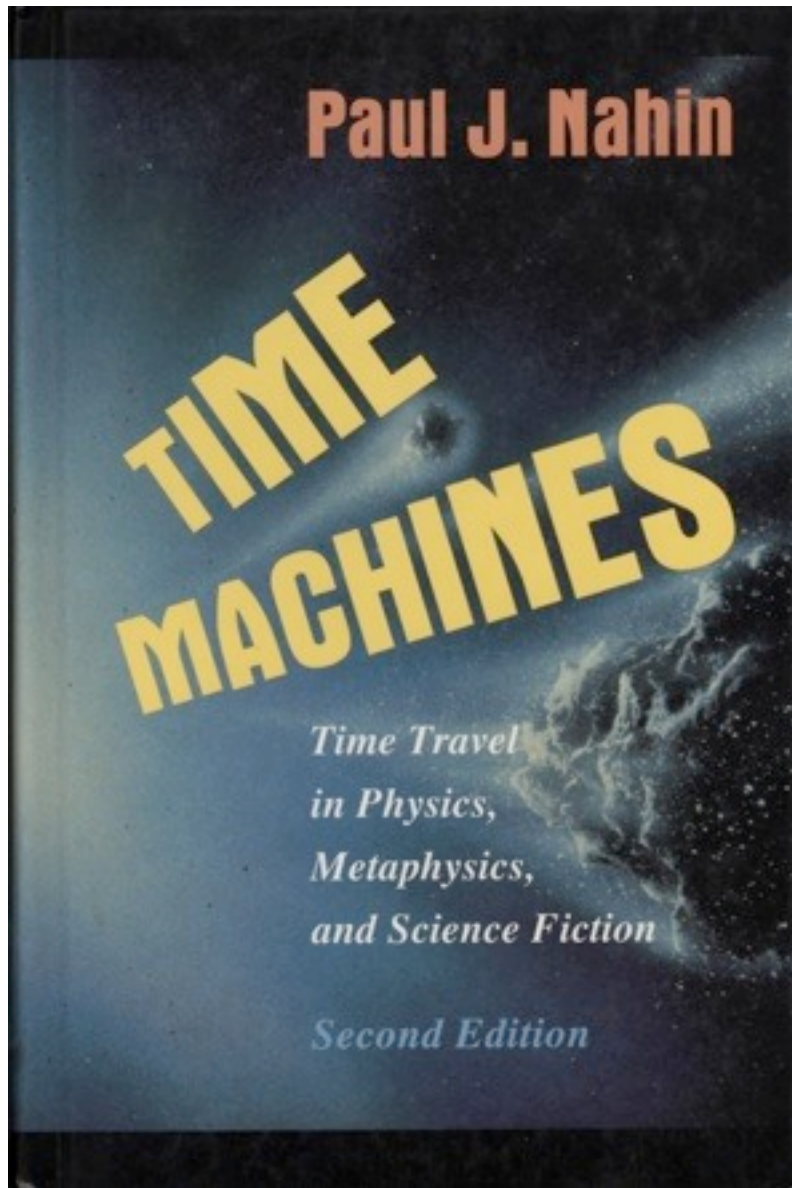
The Life of the Cosmos



A Sound of Thunder



- Eckels ... fumbled crazily at the thick slime on his boots. He held up a clod of dirt, trembling, “No, it can’t be. Not a little thing like that. No!”
- Embedded in the mud, glistening green and gold and black, was a butterfly, very beautiful and very dead.”



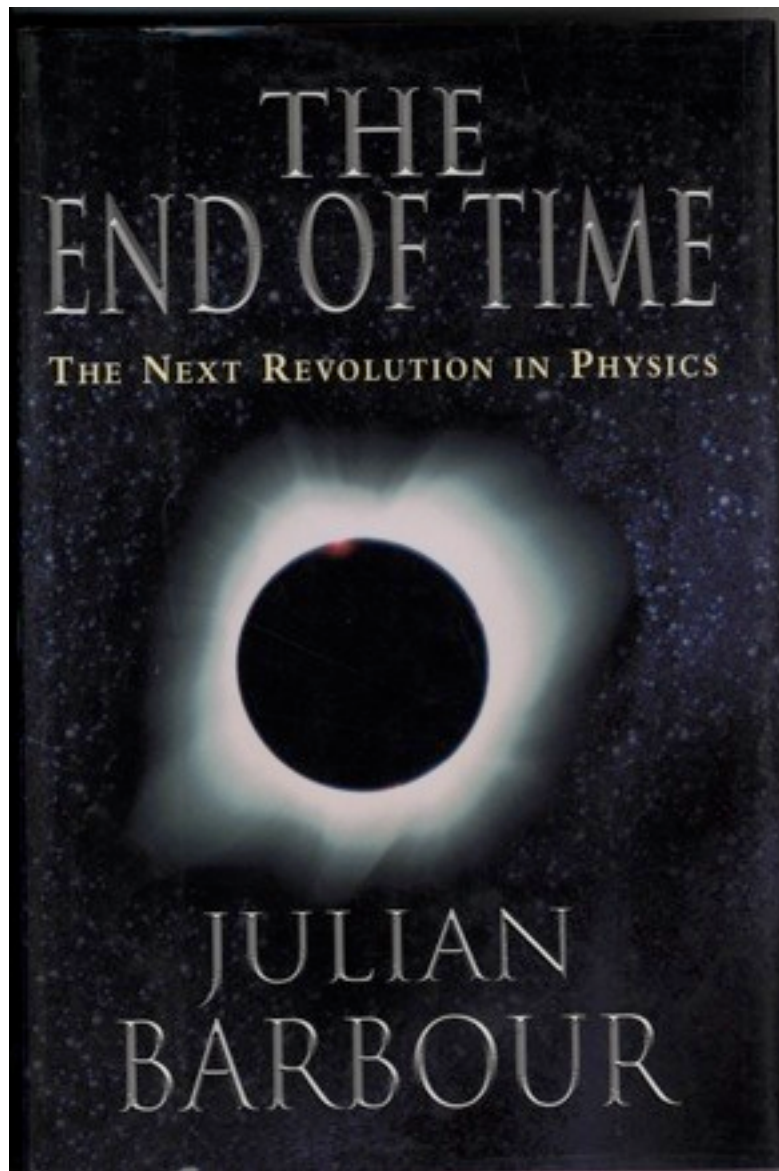
- *Why pick on grandfather? It seems that the only way to prove that time travel is impossible is to cite a case of killing one's own grandfather. This incessant murdering of harmless ancestors must stop. Let's see some wide-awake fan make up some other method of disproving the theory.” – letter to Astounding Stories*

- "The law that entropy always increases holds, I think, the supreme position among the laws of nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations - then so much the worse for Maxwell's equations....but if your theory is found to be against the second law of thermodynamics, I can give you no hope; there is nothing for it but to collapse in deepest humiliation."

– Eddington

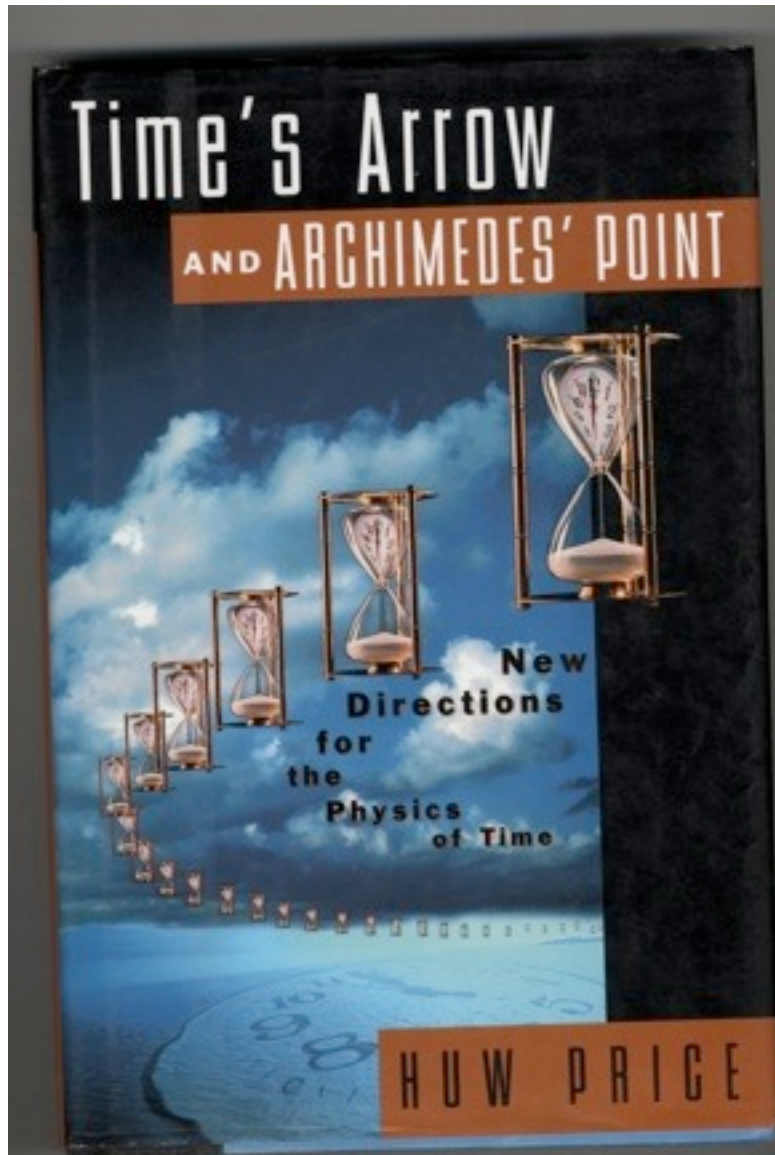
Many arrows

- ▶ Big Bang - the Mother of all arrows
- ▶ Radiation
- ▶ Decay
- ▶ Evolution
- ▶ Biology
- ▶ Economics
- ▶ Linguistic
- ▶ Psychology
- ▶ ...



Cognitive psychology

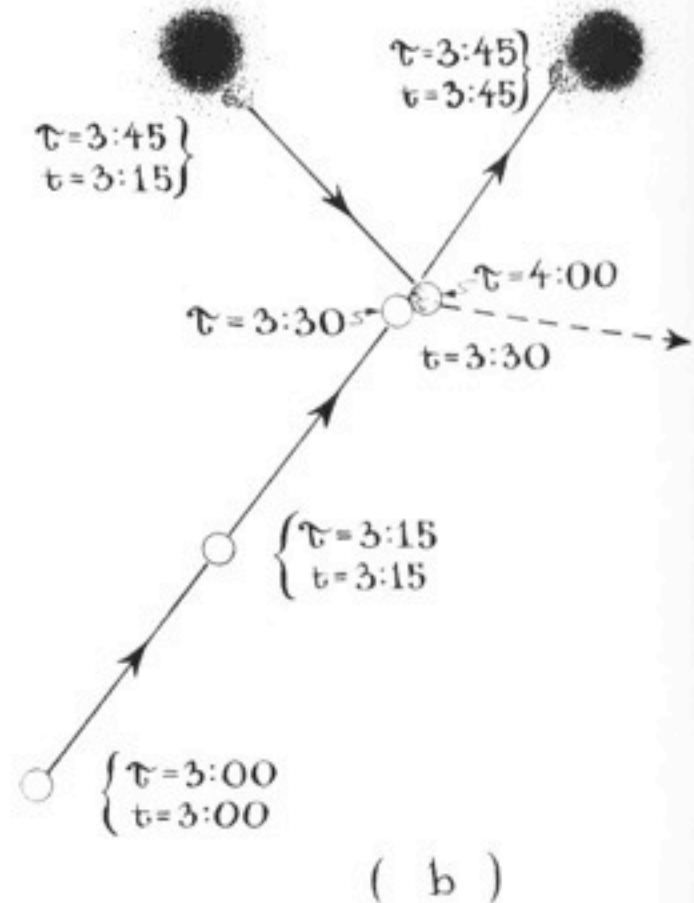
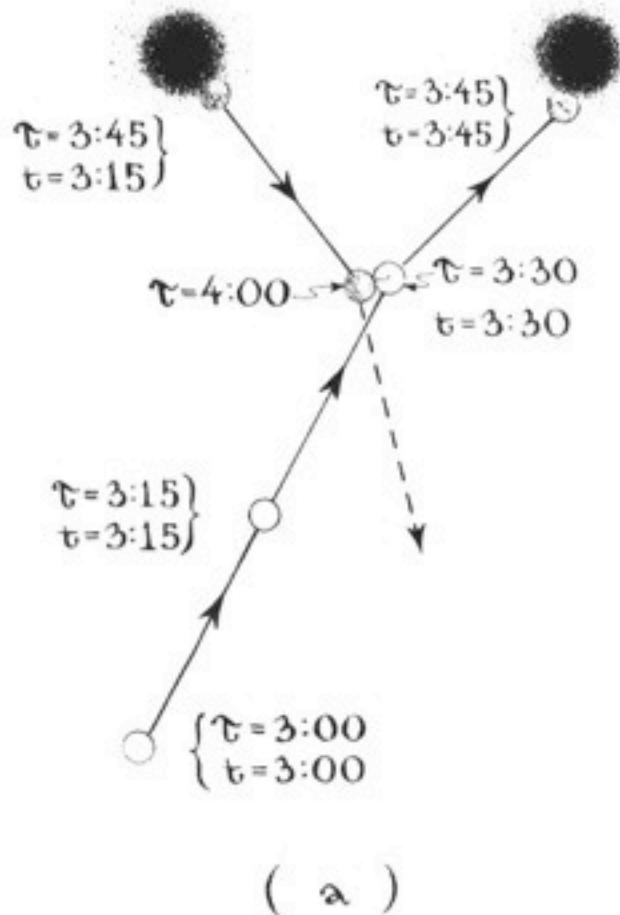




“We need to guard against the double standard fallacy--that of accepting arguments with respect to one temporal direction that we wouldn't accept with respect to the other.”

Black Holes & Timewarps

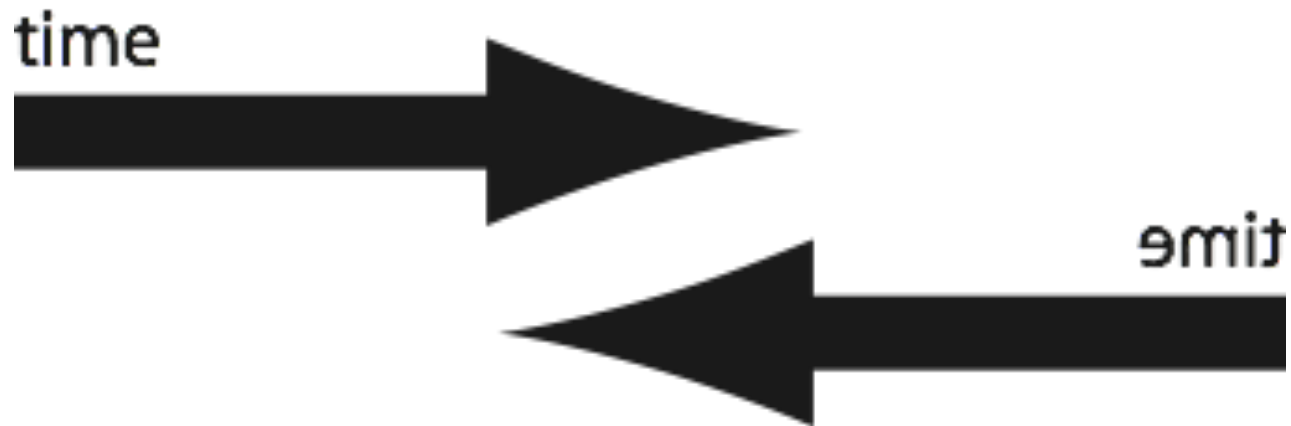
- Kip S. Thorne



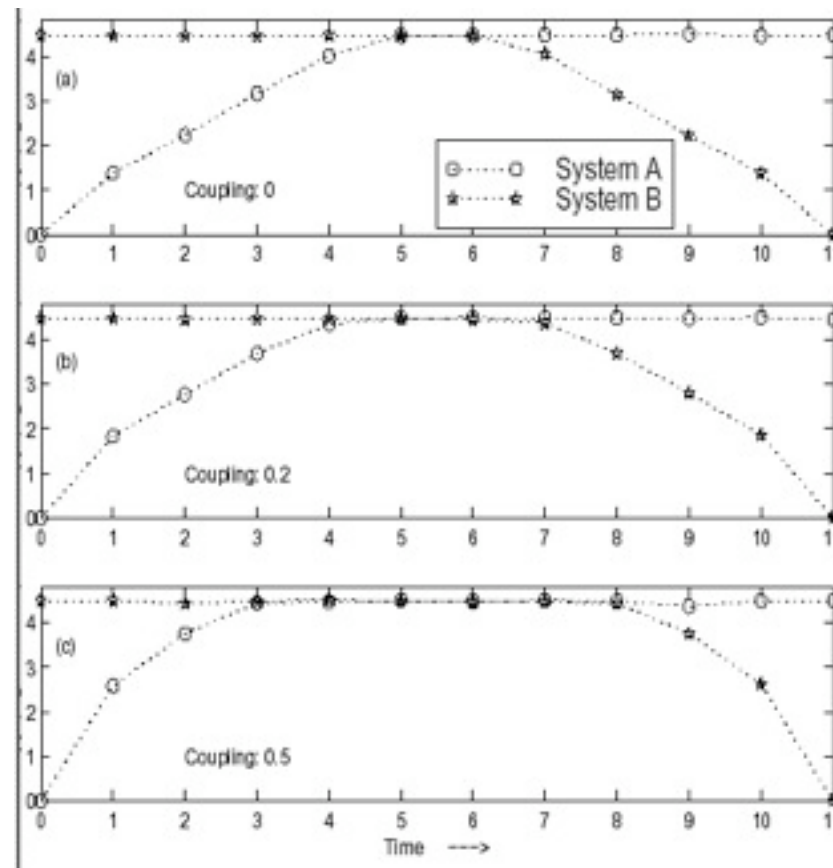
Complex time

- *"In other words, (the pilot's) life as observed from other reference frames must be consistent with his own observations just as spatial observations must be consistent. This does not necessarily mean (the pilot) can never appear in his own past, but rather that he cannot change that past after he has experienced it."*
– Asaro

Opposite Thermodynamic Arrows of Time

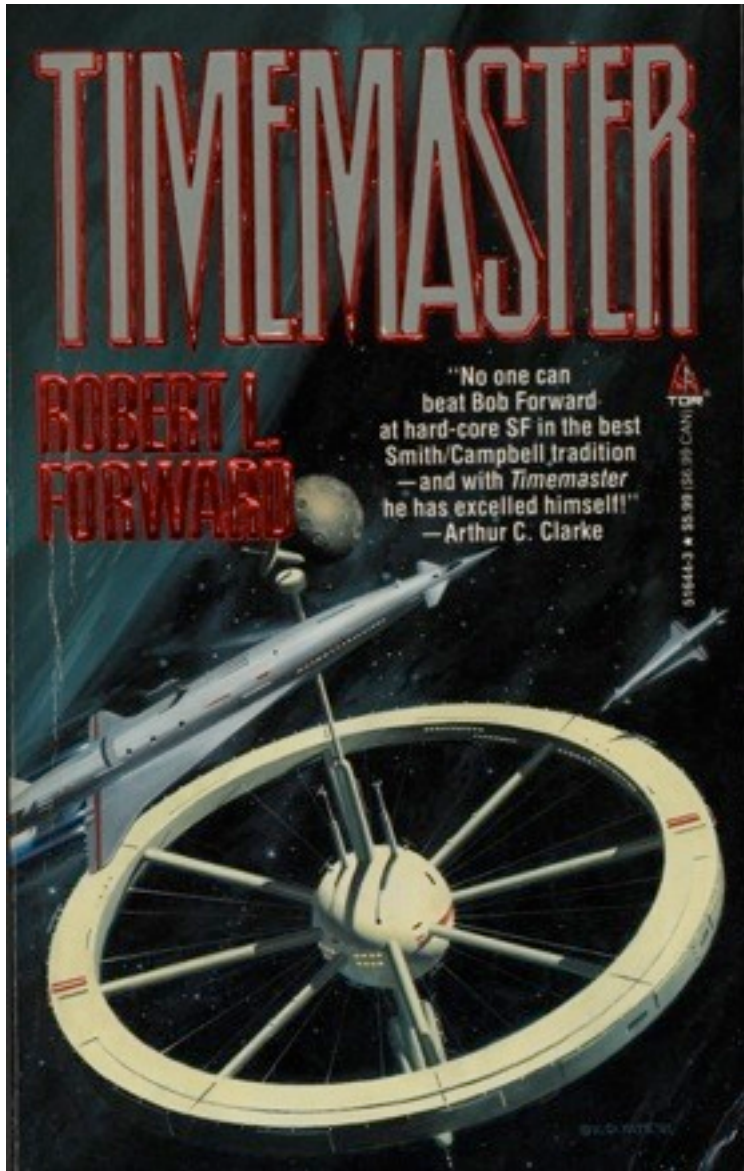


Opposite Arrows of Time (2)



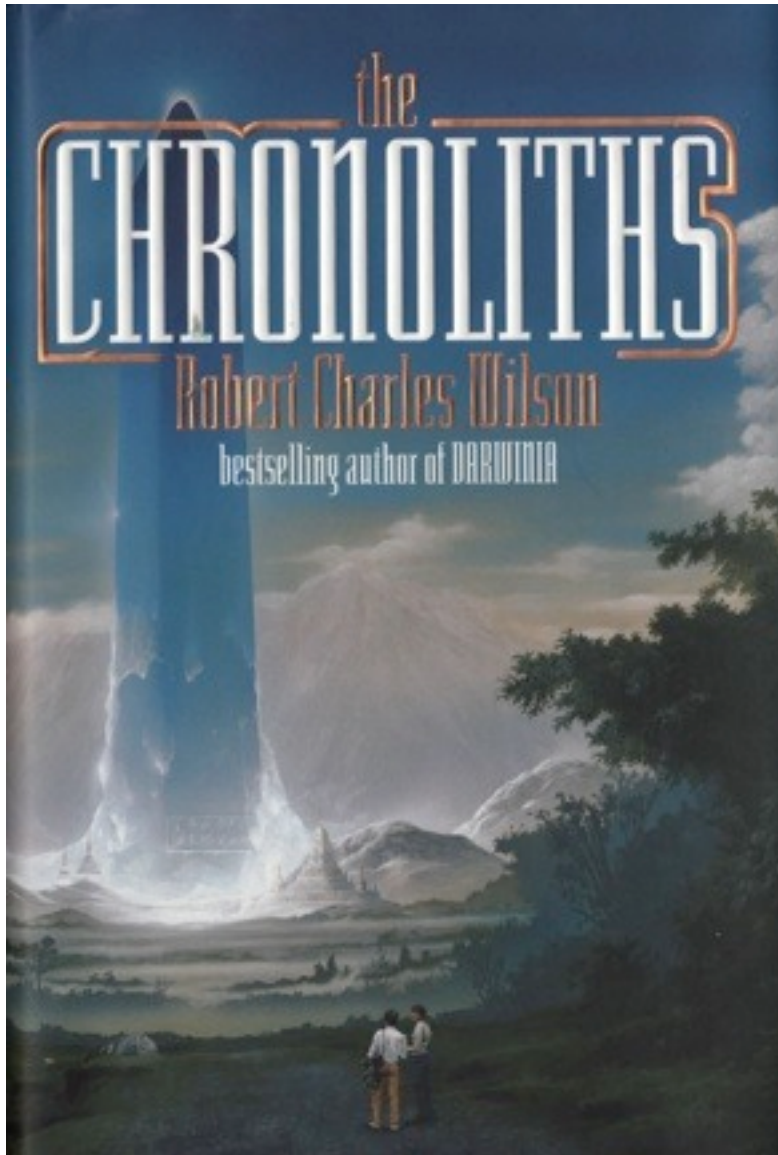
Paradox Noise

- “In any case where a signal from the future seems liable to tampering, either that signal will come through sufficiently muddled and unclear, or the overall system will otherwise conspire to subvert any schemes for tampering.”
– Peres and Schulman



If wave functions can continue backwards in time (through one of his stargates) then only self-consistent solutions are allowed.

(By analogy with Bohr-Sommerfeld quantization rules for the atom!)



- Kuin sends chronoliths 20 years & 3 months into the past to presage his intended victory...
- Like the three witches telling Macbeth a partial truth to damn him.

Coming to terms with your inner robot

- “Of course I have free will. What choice do I have?” – Irving Berlin

Elbow Room

- *“What we want when we want free will is the power to decide our courses of action, and to decide them wisely, in the light of our expectations and desires. We want to be in control of ourselves, and not under the control of others. We want to be agents, capable of initiating, and taking responsibility for, projects and deeds.”*
– Dennett

Presented for your consideration...

Levels of time

- Cause & effect
- Entropic
- Parametric
- Strings
- Loop quantum gravity

Why time travel?

- High fun factor
 - Fight foo fearlessly
- You never know
 - “That which is not forbidden is compulsory!”
- Thought experiments
 - Witness the references