

# Can we time travel?



# Is Time Travel Possible



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## TIME TRAVEL INTO THE PAST

There is no debate, even among science fiction writers, that this is completely impossible. It not only involves violations of the laws of physics, particularly the Second Law of Thermodynamics, but literally and actually involves gross logical contradictions. The idea is that mad Dr. Soandso gets into his time machine (not clearly described) and somehow goes back to ancient Rome, where he gives a translated handbook of physics and chemistry to a Roman scholar, and thus utterly changes the course of human history .... the atomic bomb, for instance, is then invented by Claudius Festus Arpinna in 350 AD.

Despite the fact that even the writers agree time trips into the past are an impossibility, they love to play with them, because of the plot complications that can be generated by the logical contradictions that arise..... The time-travel short story to end all time-travel short stories is All You Zombies! by Robert A. Heinlein.

Rory Coker

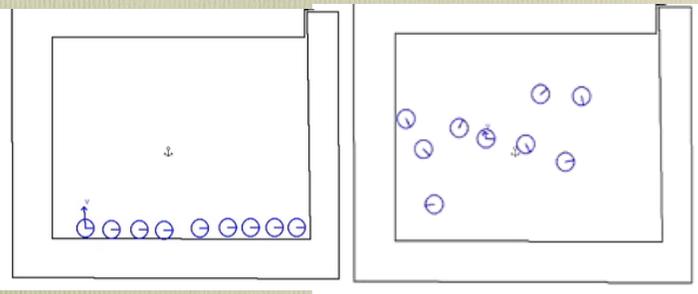
## Time travel is

- impossible: forbidden by increase of entropy
- impossible: forbidden by relativity
- impossible: forbidden by requirement that universe must have positive energy everywhere.
- impossible: time must flow and we have no control over it
- impossible: forbidden by logical paradoxes
- impossible: forbidden by cosmic censorship (Steven Hawking)

## Time travel is

- possible in theory, but in practice impossible (e.g. costs too much energy)
- possible: paradoxes avoided by many-worlds model
- possible: past can be seen as movie, but not altered
- possible: free-will is an illusion, so it is irrelevant!
- irrelevant: time is an illusion

• Which movie runs forward?

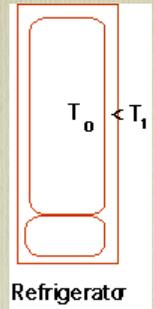


## Increase of Entropy?

- Unsatisfactory for forbidding time travel since it doesn't forbid travel into the future
- (let's skip tomorrow and move on to Sunday!)

Note we can decrease entropy locally as long as it increases overall

Initially room and fridge at same temp., afterwards  $T_0 < T_1$   
So we would need a "time-refrigerator" to travel into the past

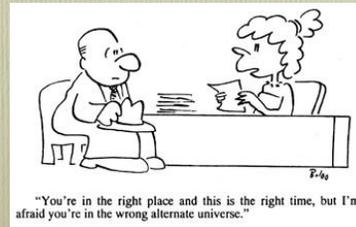
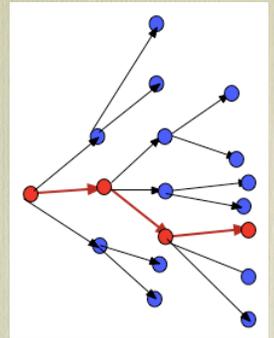


IF we could time-travel, we run into problems

- **The "Grandfather Paradox"**; if I invent a time machine, I can time-travel to the past, murder my grandfather before my father is conceived, so I am not born so I cannot invent the time machine so I cannot .....
- **The "Where are they" paradox**; if time travel is possible, why aren't we over-run by time tourists?

## Many worlds theory

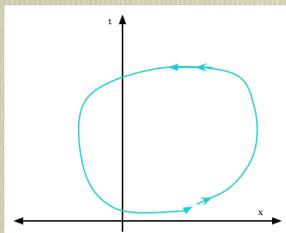
Many-worlds theory: Everett (1957) . Every time a measurement is made, the universe subdivides into separate universes that correspond to every possible outcome



Avoids observation problems, but not testable (?) and not very economical!

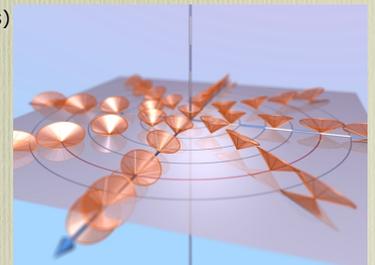
## So can we build a time-machine?

- Now we know the question to ask;
- Can we arrange for world-lines to be closed?

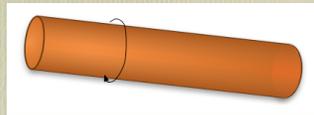


## Relativity does **not** forbid time-travel

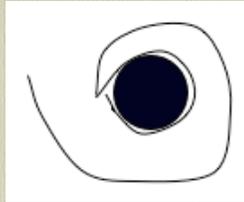
- Godel invented a model universe consistent with GR where time travel is compulsory
- We don't live in it: it has a centre (ours has no centre)
- it is not homogenous (ours is)
- It rotates (ours doesn't).



- Tipler showed that can construct time machine from infinite rotating massive cylinder



Light cone gets bent round cylinder, so starting point lies inside light cone



## Maybe time simply "flows"

You could not step twice into the same river; for other waters are ever flowing on to you. Heraclitus

River analogy is not uncommon: e.g

Time is a sort of river of passing events, and strong is its current; no sooner is a thing brought to sight than it is swept by and another takes its place, and this too will be swept away. Marcus Aurelius

## Oh god, our help in Ages Past

- Time, like an ever rolling stream,  
Bears all its sons away;  
They fly, forgotten, as a dream  
Dies at the opening day.
- **Isaac Watts**

e.g. Music

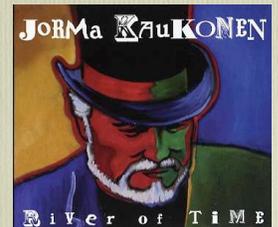
"From me flows that which you call time"

(Takemitsu)

- "Of time and rivers flowing  
The seasons make a song."

**Peter Seeger**

- River of Time (Jorma Kaukonen)



But in reality the analogy of time flowing is not very useful:

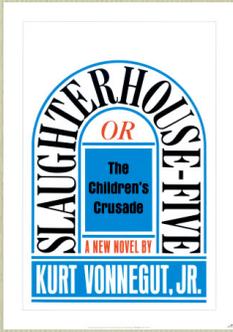
flow of something is "rate of change"

e.g. flow of a river is amount of water that passes you in a given time.

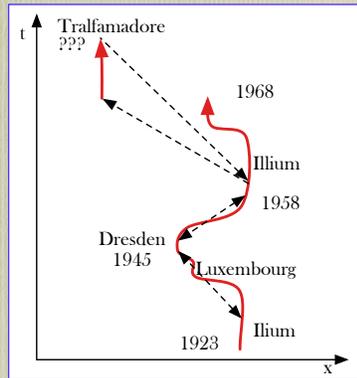
If time is to flow, it is the amount of time that passes you in a given time .... at the rate of 1 second per second?

## Unknown physical principle?

- "Cosmic Censorship"
- Not an argument



Billy Pilgrim has become unstuck in time



*So it goes*

## Free will doesn't exist

There was a young man who said "Damn  
It is suddenly borne on me that I am  
An engine that moves  
In predestinate grooves  
I'm not even a bus, I'm a tram."

## Time as an Illusion

- Can evade all the paradoxes if time does not exist in the way we think it does
- Suppose "Slaughter-House Five" is correct...
- Tralfamadorians have access to all of time: our consciousness is such that we have access to "now" ONLY
- "Among the things Billy Pilgrim could not change were the past, the present, and the future."

## Time as an illusion:

### Is the Queensway ordered in time?



- What does a clock measure?
- Interval between events.
- What does "prediction" mean?
- Starting from now, saying what will happen (and in general we cannot do it)
- When did time measurement start?
- Humans: probably ~ 10000 BC.
- Do we experience time in the same way?
- NO; time dilation and twin paradox.
- Why does time pass more quickly as we get old?
- Probably decrease in number of novel experiences.
- What defines the direction of time?
- Increase of entropy, maybe (ultimately) behaviour of particles with handedness.
- Physiological Time: what is a biological clock?
- Almost all are linked biochemical reactions.

- How short a time can we perceive?
- Directly ~ 20 ms, indirectly (via sound) ~ 50µs.
- What exactly is causality?
- One event that causes a second: defined via light cone.
- Is time travel possible?
- Don't know.
- If so, why can't we do it?
- See above.
- If not, what forbids it?
- See above.
- How do we know that two clocks measure the same time?
- They don't, in general.
- How are time and space linked?
- Manifestations of 4-D space-time.
- Is time "smooth"?
- Maybe.

- Did time begin?

- Maybe.

- Will it end?

- Maybe.

- If time is an illusion, why

a) do we care about it so much?!

b) can we measure it to such fantastic accuracy!?

# What is Time?

## I wish I knew